

August 1997

Mobile Radio Technology[®]

Technical information for paging, SMR and private wireless networks.

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dispatch

Paging control links

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APCO how guide

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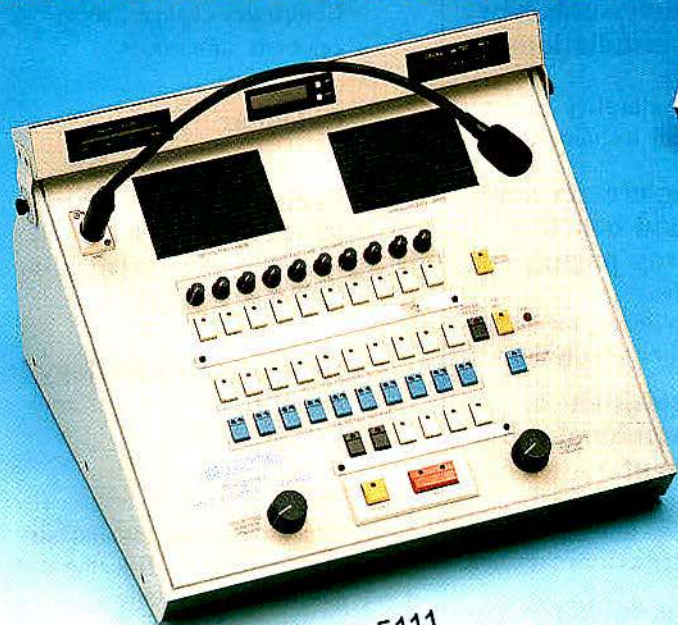
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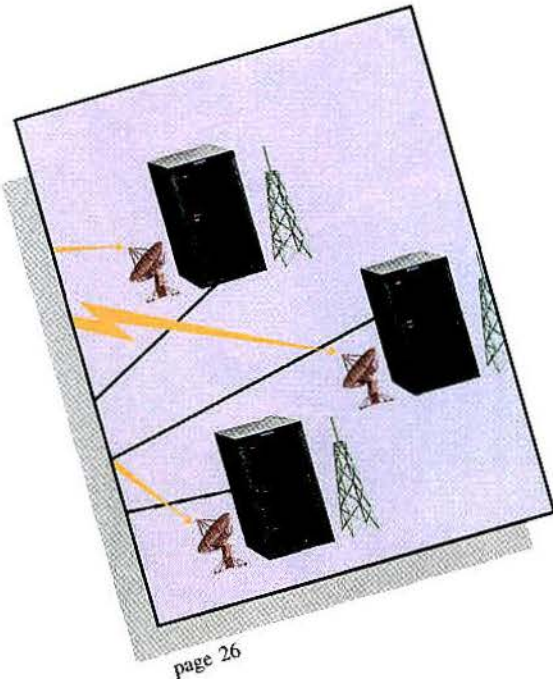
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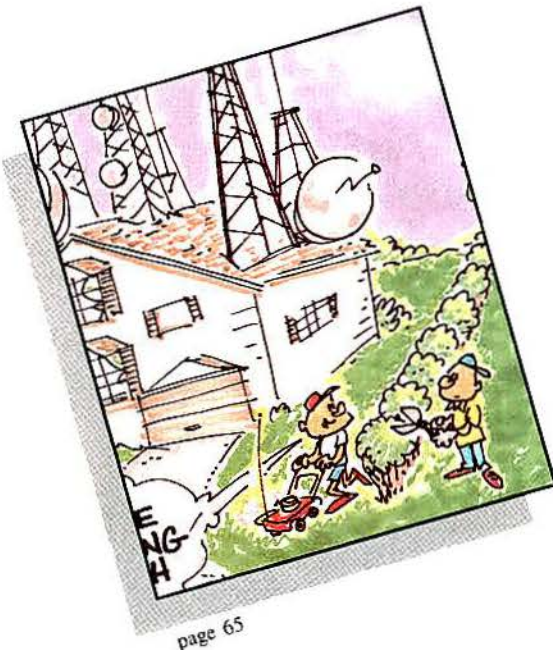
On the cover: Frequency-domain reflectometry-based antenna system analyzers simplify measurement for cellular and PCS expansion. *Photo courtesy of Anritsu Wiltron, Morgan Hill, CA.*

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Companies change hands, celebrate milestones



Roger and Gayle Block, founders of PolyPhaser, Minden, NV, and Jack Reichler, founder of Meridian Communications, Calabasas, CA, have sold their businesses. These names were part of the industry when *Mobile Radio Technology* began publishing in 1983. Another well-known company, E. F. Johnson, is changing hands, and Decibel Products marks 50 years in business.

PolyPhaser

As I remember Roger telling the story about a dozen years ago, Gayle and he started their business in Kissimmee, FL, near where they had worked at Disney World. As an electrical engineer, Roger developed some devices to protect equipment after he saw the effects of lightning damage on electronics at the theme park. Gayle and he formed a company to manufacture lightning protection products, later moving it to Nevada where lower humidity resolved some manufacturing problems.

Mostly during the 1980s, Roger wrote articles for various publications. We've published 14 of his articles, and his writings on the subject remain popular. His articles helped to establish our magazine

as a source of technical information about commercial radio communications. These days, publications available directly from PolyPhaser contain his most up-to-date work.

Roger and Gayle remain with PolyPhaser as it finishes 18 years under their ownership and as it begins a new period of growth as part of Smiths Industries, London. John Cole, who was named president of PolyPhaser in 1996, continues in that role.

Meridian

Meridian Communications, which develops and manages antenna sites in Southern California, has been purchased by American Tower Systems. Jack Reichler founded Meridian 41 years ago with his first antenna site atop the Hollywood Hills. On June 19 of this year, the company staff honored Jack by renaming and dedicating the Meridian site at Saddle Peak as the "E. Jack Reichler Telecommunications Facility." The highlight of the ceremony was the unveiling of a bronze plaque, formally renaming the 1,200-square-foot shelter and 150-foot self-supporting antenna tower.

Jack saw Meridian grow from its initial site in 1956 to a company with more than 85 sites today. Saddle Peak is a favorite of Jack's. "I'm particularly happy that it will be at Saddle Peak," he said, speaking of the renamed facility, "since I will be able to look up at the mountains and see it from my home."

Johnson

One more transition to note: E. F. Johnson, Burnsville, MN, has signed a letter of intent under which it is set to be acquired by Transcrypt International, Lincoln, NE, on or about Aug. 1. Founded in 1923 by Edgar F. Johnson in Waseca, MN, Johnson has had its turn with amateur radio, electronic com-

ponents, citizens band, conventional land mobile radio, remote meter reading, telemetry and trunked radio.

Western Union purchased Johnson for \$60 million in 1982, primarily for its cellular capability. Diversified Energy bought the company for \$30 million in 1985, primarily for its remote meter reading capability. Diversified merged with Arkla in 1990, and in 1992, investors William Weksel and Robert Davies bought the company for an undisclosed amount estimated between \$30 million and \$40 million. They sold the components and telemetry divisions, turning Johnson into a pure-play radio company.

Transcrypt, with which Johnson has done substantial business for the past five years, will pay \$34 million for the company. The acquisition is expected to give Transcrypt more strength in competing for APCO 25 digital radio sales and better representation in foreign markets for its voice privacy and information security products.

Decibel Products

Tracing its roots to a five-person electrical supply house founded in 1947, Decibel Products marks 50 years in business. "When Tom McMullen and Jerry Stover started the Communications Engineering Company (CECO), the typical wireless system was a lowband, two-way radio system," said Peter Mailand, Ph.D., president of the Decibel Products Division of Allen Telecom Group.

CECO's first wireless product was a ground plane antenna made of aluminum, a relatively new material at the time. The company created an antenna manufacturing division, now known as Decibel Products. The division now makes nearly 5,000 antenna models.

—Don Bishop



Gayle Block



Roger Block



Jack Reichler (right) and his son Richard unveil the bronze plaque.

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August

10-14—International Association of Public-Safety Communications Officials (APCO) National Conference, Westin Hotel, Charlotte, NC. Contact: 904-322-2500.

September

10-12—Personal Communications Showcase, sponsored by the Personal Communications Industry Association, Dallas Convention Center, Dallas. Contact: 800-326-8638.

October

6-8—Industrial Telecommunications Association, Annual Conference and Membership Meeting, ANA Hotel, Washington, DC. Contact: Karin Norton, 703-528-5115.

27-29—Wireless Apps, sponsored by the Cellular Telecommunications Industry Association, Seattle Convention Center, Seattle. Contact: Francesca Dea, 702-739-4025, or Tim Ayers, 202-736-3203.

November

6-7—AMTEX, sponsored by the American Mobile Telecommunications Association, Hilton at Walt Disney World Village, Orlando, FL. Contact: 202-331-7773.

6-8—Second International Congress on Commercial Trunked Radio, sponsored by the International Mobile Telecommunications Association, Hilton at Walt Disney World Village, Orlando, FL. Contact: 202-331-7773.

12-16—Communications Marketing Conference, sponsored by the Communications Marketing Association, Holiday Inn International Drive Resort, Orlando, FL. Contact: Bernie Brownson, 303-371-8182.

21—Radio Club of America, Communications Symposium, 88th Anniversary Dinner and Awards Presentation, New York Athletic Club, New York. Contact: Gerri Hopkins, 908-842-5070.

1998

February

23-25—Wireless, sponsored by the Cellular Telecommunications Industry Association, Georgia World Congress Center, Atlanta. Contact: 212-964-7000.

March

1-4—ENTELEC, sponsored by the Energy Telecommunications and Electrical Association, Marriott River Center, San Antonio, TX. Contact: 281-357-8700.

April

20-23—Expo Comm/Comdex, sponsored by E.J. Krause & Associates, McCormick Place, Chicago. Contact: 301-493-5500.

22-24—International Wireless Communications Expo, co-sponsored by Mobile Radio Technology, Las Vegas Convention Center, Las Vegas. Contact: 800-288-8606.

May

18-21—Supercomm, sponsored by USTA and TIA, Atlanta. Contact: 202-326-7300.

18-21—Vehicular Technology Conference, sponsored by IEEE Vehicular Technology Society, Westin Hotel, Ottawa, Canada. Contact: 908-562-3870.

June

20-22—Canadian Wireless, sponsored by the Canadian Wireless Telecommunications Association, Metro Toronto Convention Center, Toronto, Canada. Contact: 613-233-4888, ext. 102.

28-July 2—UTC National Conference & Exhibition, sponsored by UTC, The Telecommunications Association, Hynes Convention Center, Boston. Contact: 202-872-0030.



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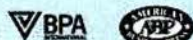
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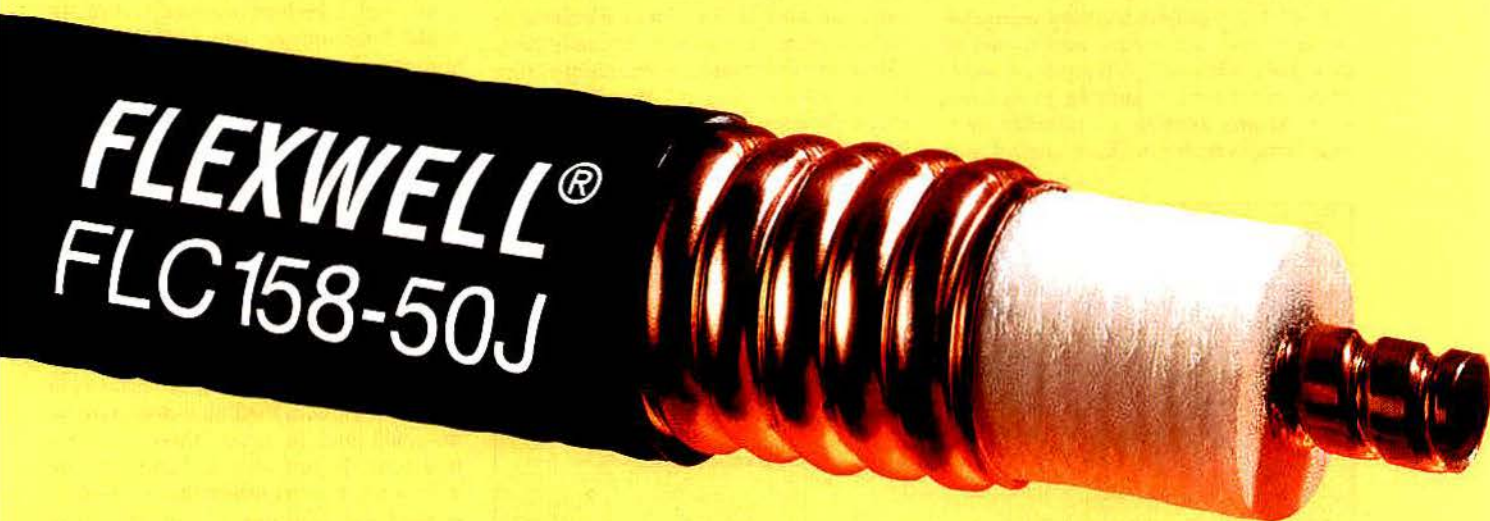
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CW11

Troublesome telco line problems

By Harold Kinley, C.E.T.

Ever had one of those days when nothing seems to work according to theory? Usually, it is something simple, and we technicians often tend to overlook the simple problems in pursuit of the more complex and weird stuff.

After working many long hours for several weeks in an effort to meet a startup deadline for our new centralized dispatch center, my assistant, Hilton Crews, and I were beginning to see the light at the end of the tunnel. Little did we know that the light would turn out to be a speeding freight train. After all, the most difficult part of the journey was behind us, and the remaining tasks were fairly simple in comparison—or so we thought!

The Problem

Part of this project included the installation of quite a few base stations and all that goes with that (antennas, control lines, grounding, lightning protection, etc.). At one location we installed three base stations with associated control lines

leased from telco to allow remote control from the central dispatch point. The remote control system used the standard remote control audio tones (2,175Hz for transmitter keying).

After getting everything installed and wired up on both ends, we were ready to run initial tests on the three stations. The basic block diagram is shown in Figure 1 below.

Ready, set, go! It works!

No, it doesn't.

Yes, it does!

Simply put, it worked intermittently. With 10 transmitter keying signals sent down the line, the transmitter would not key 100% of the time. The keying percentage would vary from 30% to 70%, with each series of 10 keying control signals.

Before installing the base stations at the remote sites, we had checked each one with the dispatch console to make sure each one worked. This included transmitter keying and modulation. The only thing different now was the interconnecting telco line—or was it? We decided to check the telco line for loss and frequency response. Maybe there was a severe at-



Photo 1: This SNIX filter was used in the application described here. Photo courtesy of SNC Manufacturing, Oshkosh, WI.

tenuation notch at the 2,175Hz keying control frequency. It can happen, but on all three lines?

A fairly complete frequency response test did not indicate such a problem. From the test results, it would seem that the telco line should work. Hilton and I were using two identical-line testing instruments with a built-in intercom so that we could communicate and coordinate our test procedure. It was during one of these voice messages that I noticed that Hilton's voice sounded as if he were talking through a fan. I communicated this to him, and he also noticed the "fan-voice" sound. It sounded much like a broadcast radio with a bad filter capacitor in the power supply, with the voice riding on top of the 60Hz hum (120Hz in the case of a full-wave rectifier).

As it turned out, this was the clue that ultimately led to the cure. However, another twist would lend more confusion to the issue. Having tried almost everything we could think of, it was almost desperation time! If you look at Figure 1, you will see a line protector that is used to protect the equipment from lightning surges on the telco line. Given our past experience with these devices, we never suspected that this device could play even a minor role in the problem we were experiencing. In a last-gasp attempt to find some common denominator to the

(continued on page 64)

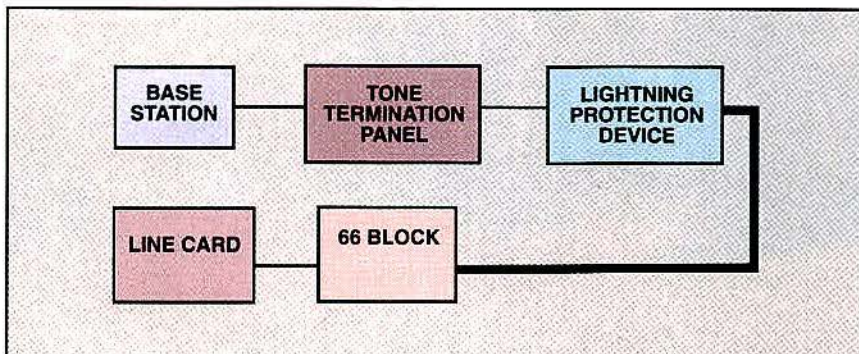


Figure 1: A long leased telco line interconnects the remote location to the dispatch center. The heavy black line represents the leased telco line.

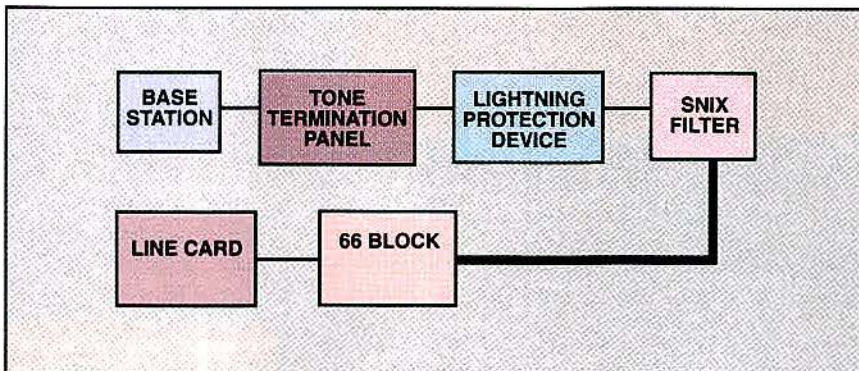


Figure 2: The SNIX filter is inserted in the line at the remote equipment end.

Kinley, a certified electronics technician, is regional communications manager, South Carolina Forestry Commission, Spartanburg, SC. He is a member of the Radio Club of America. He is the author of *Standard Radio Communications Manual: With Instrumentation and Testing Techniques*, which is available for direct purchase. Write to 204 Tanglewylde Drive, Spartanburg, SC 29301. Kinley's email address is hkinley@aol.com.

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Frequency domain reflectometry aids new antenna installations

*New antenna system design trends complicate performance verification.
Newly developed analyzers simplify the measurement techniques.*

By Ken Harvey

Cellular and PCS expansion continues at a brisk pace in 1997. As new competitors seek subscribers, factors such as coverage, capacity, cost and quality are receiving greater emphasis. Simply activating a radio network no longer guarantees success. Furthermore, attracting thousands of low minute-per-month subscribers produces meager profits. The best customers—those who generate the high day-time minutes—migrate to those providers offering the best service package.

Base station engineers have responded with a new generation of antenna systems equipment including duplexers with built-in, receive-side LNAs; directional antennas, superconducting filters, interference sensing dynamic frequency assignment, interference monitors, repeaters and horizontal and vertical isolation. Although these antenna system designs improve quality and capacity, they also present new performance verification challenges.

It helps to be aware of the trends behind new antenna installation tests and the measurement techniques used to verify performance. Specifications and operating ranges noted herein apply specifically to three new Site Master models from Anritsu Wiltron's series of portable cable and antenna analyzers for ranges of 600MHz–1200MHz, 1,250MHz–2,350MHz and 1,750MHz–2,500MHz.

Improving RX signal strength

Duplexers separate the transmit and receive signals from a single antenna feed. Most base station designers are migrating to a design used for many years in military systems. A receiver preamplifier is installed close to the antenna. A duplexer or filter precedes the low-noise amplifier (LNA) to limit input bandwidth and to

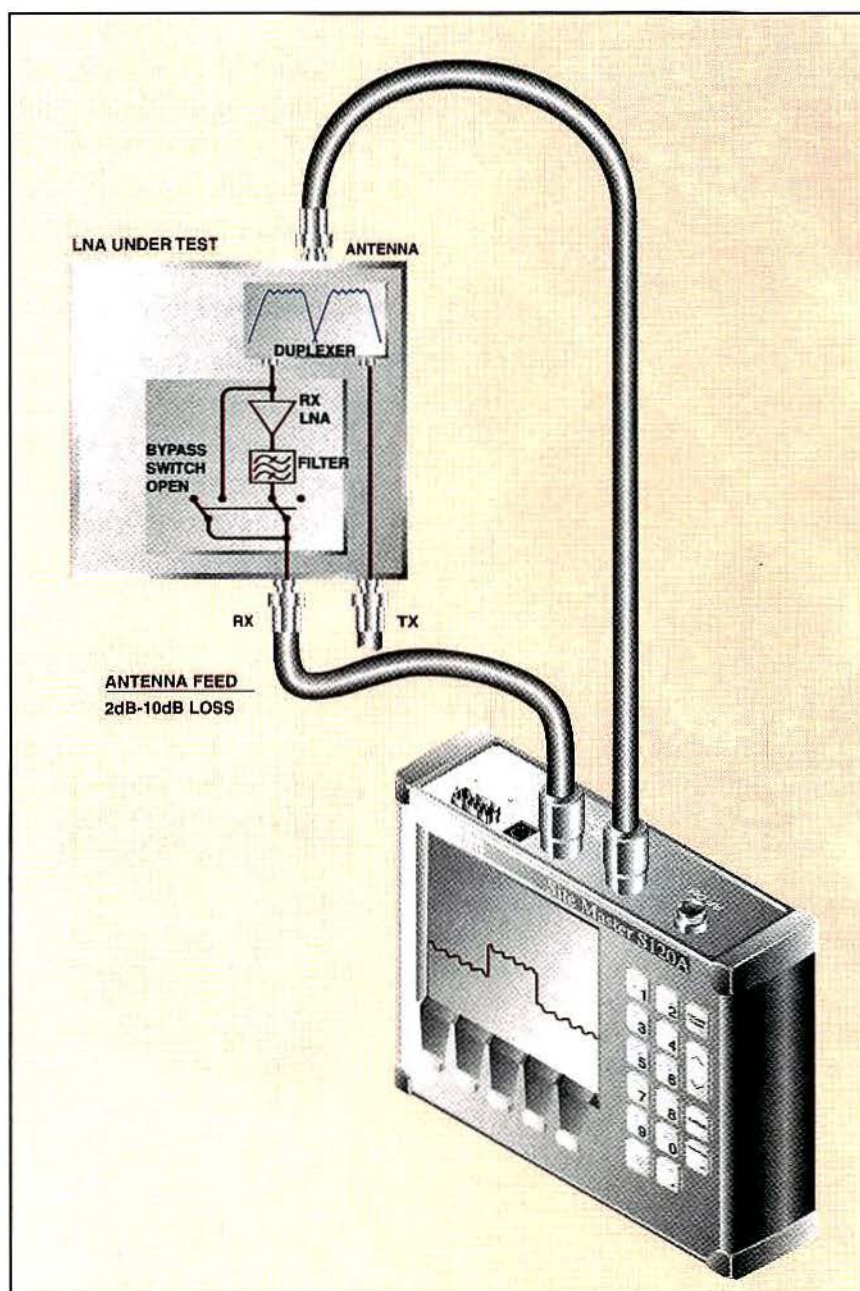
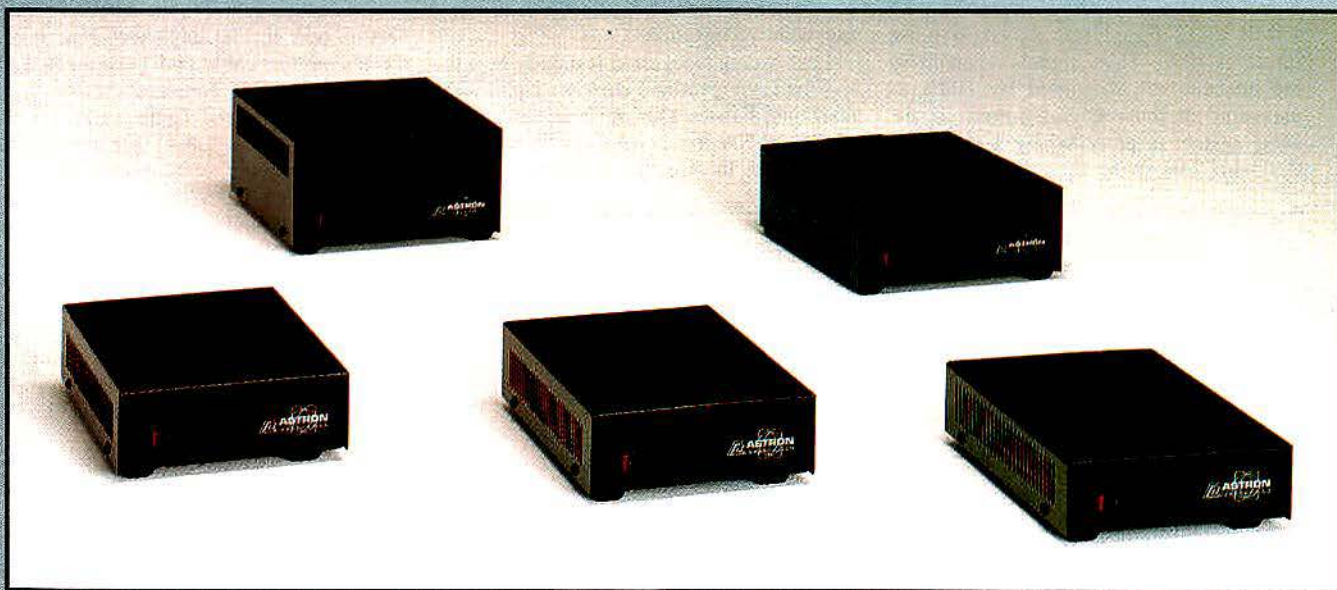


Figure 1. Before cables are sealed, the transmitter cable can be used to inject the test signal into the Duplexer/LNA's antenna connection.

Ken Harvey is product marketing manager at Anritsu Wiltron, Morgan Hill, CA.

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SS-25	20	25	2 7/8 x 7 x 9 3/8	4.2
SS-30	25	30	3 3/4 x 7 x 9 5/8	5
SS-25M*	20	25	2 7/8 x 7 x 9 3/8	4.2
SS-30M*	25	30	3 3/4 x 7 x 9 5/8	5

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minimize unwanted interference. This design boosts signal-to-noise ratio by reducing system noise figure.

For example, a receive antenna feed with 6dB of loss feeding a receiver with a 4dB noise figure has a system noise figure of 10dB. Thus, signals received by the antenna are degraded by 10dB as measured at the receiver output. If the same system is preceded by a preamplifier with 2dB noise figure and 20dB of

gain, the system noise figure is a respectable 2.2dB—an improvement of 7.8dB. Today, LNAs and duplexers can be built with high reliability and reasonable cost, so implementation of the design is receiving wide recognition.

Less widely recognized is exactly how to test the LNA gain and duplexer bandwidth after installation. During installation, the duplexer/LNA test is relatively straightforward. Once the weather seals are applied,

the test procedure is more complex.

Installation verification is facilitated by connecting a test input cable (typically the installed transmitter feed cable or other installed cable) to the antenna's connection port on the duplexer/LNA. First, the transmitter cable end is connected to the receiver cable end, and the test analyzer is normalized (path calibration). Next, the duplexer/LNA assembly is inserted between the feeds as shown in Figure 1 on page 10. When the dc voltage supply is applied, the duplexer/LNA's gain and bandwidth is easily viewed on the analyzer's display. If duplexer bandwidth verification is not a concern, the procedure may omit the cable-to-cable connection. Instead, path calibration is performed through an LNA bypass switch, which is closed whenever the dc bias voltage is removed.

Once the antenna is attached and the connectors are sealed, injecting a test sig-

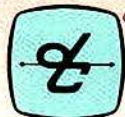
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During installation, the duplexer/LNA test is straightforward. Once the weather seals are applied, the test procedure is more complex.

nal and normalizing the response is more challenging. There are two possible signal injection paths, the transmitter feed through the duplexer or through an alternate, co-located antenna to the duplexed antenna. Depending on the design of the duplexer, the filter skirt roll off between the transmitter and receiver frequencies may be shallow enough to pass a measurable test signal. However, the path calibration vs. frequency has a severe slope—equal to the sum of the receiver and transmitter filter skirts RF attenuation. Further, as systems designs are updated, transmitter-to-receiver isolation is likely to improve. Presuming that test procedures should support long-term maintenance, it is difficult to advocate use of the transmitter feed connection for receiver LNA test signal injection.

Test signal injection using a second antenna has several variations, depending on antenna type. The simplest case is injection through an omnidirectional

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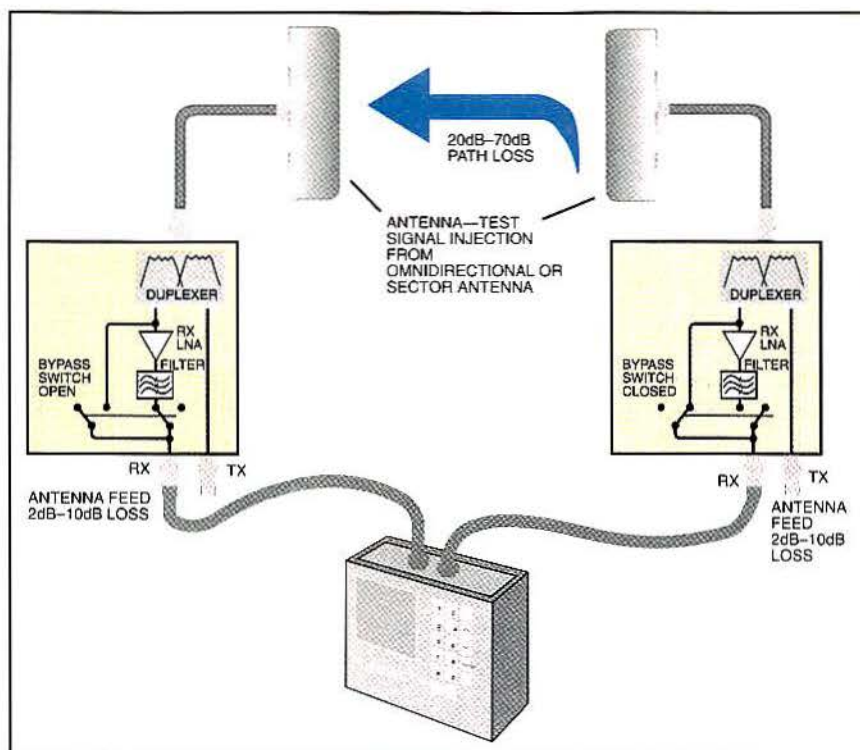


Figure 2. After the weather seals are installed, RF test signals should be injected through a second antenna.

antenna. Even if the duplexed antenna is directional over a specific cell sector, its isolation to an omnidirectional antenna is typically a reasonable 20dB to 40dB. The test signal is coupled largely through the directional antenna's back lobes.

If the only available antenna is another duplexed sector antenna, the normalization task must deal with more significant antenna-to-antenna isolation. Isolation can be 70dB at some frequencies, thus the analyzer must sense the low signal level and average appropriately to achieve a flat, normalized baseline. Adding 5dB for each of the cables, duplexers, and jumpers yields a total path loss of 80dB. For a typical laboratory network analyzer or a spectrum analyzer and tracking generator combination, the 80dB dynamic range is nearly the maximum of the standard operating mode. Filter bandwidths, attenuation and averaging must be adjusted to reduce the effects of noise and to obtain a stable calibration. By contrast, an FDR-based antenna system analyzer automatically applies averaging when measuring low signal levels. Because of its design, additional filtering is unnecessary. Sweep speed is maintained.

Figure 2 at the left shows the

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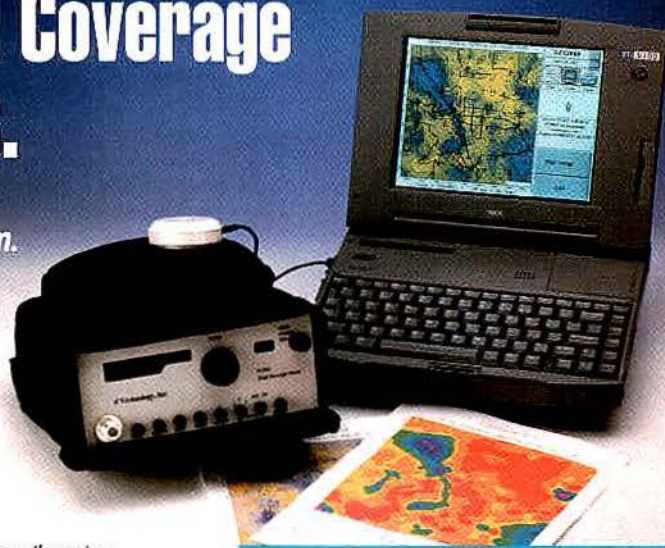
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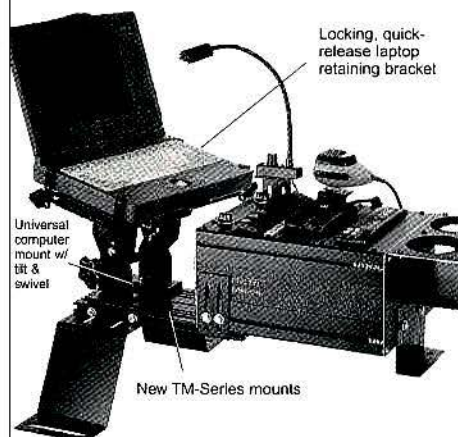
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normalization path through the bypass switch, duplexer and injection antenna into the antenna attached to the unit under test, the duplexer/LNA. For the normalization step, both bypass switches are in the closed position. During measurement, dc power is applied to the duplexer/LNA under test. The analyzer will display the LNA's gain response.

Improving sectorization

As far as the antenna system is concerned, improving sectorization is largely a matter of antenna position and pattern control. The benefit of sectorization is capacity improvement and reduced cell-to-cell RF interference. Other benefits are related to handoff

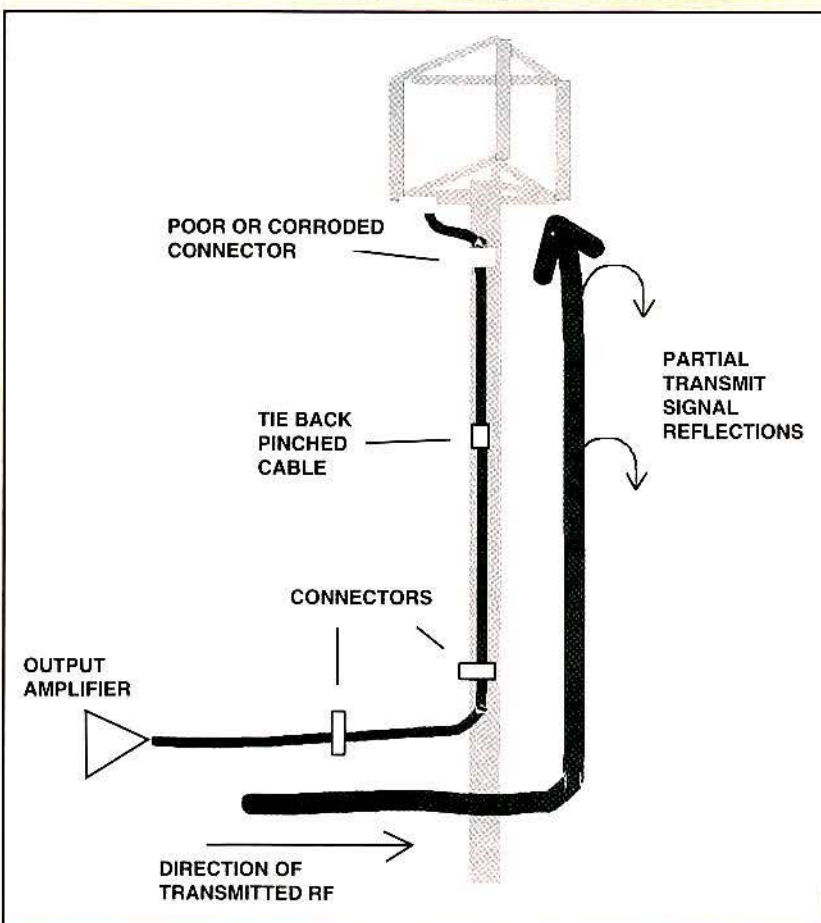
controls, but this is a minor concern for modern handoff control algorithms.

It is common to mount all antennas at the same elevation, and with the relatively modest isolation requirements to date, most antennas are able to pass specifications. However, new antenna systems are demanding higher isolation. One clever approach involves using standard, inexpensive panel antennas that are simply mounted at differing vertical elevations. The fundamental installation issue is mounting the antenna in such a position that the specified isolation performance is achieved. Following installation, antenna isolation data should be stored to a PC database. The historic test data helps verify performance following storms or

Transmission Line Fundamentals

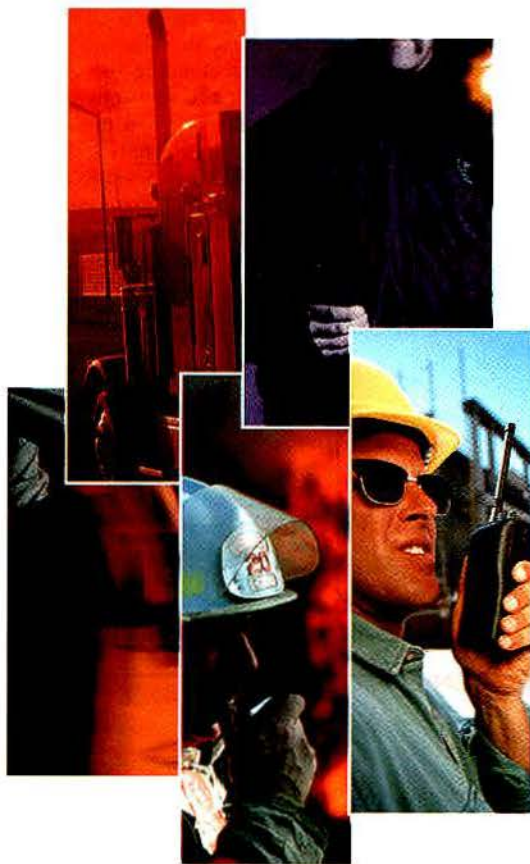
No transmission line component has a perfect impedance match. At any impedance mismatch, some of the energy of an incident signal will be

reflected backward toward the source. If these reflections are excessive, the antenna system will not operate properly.



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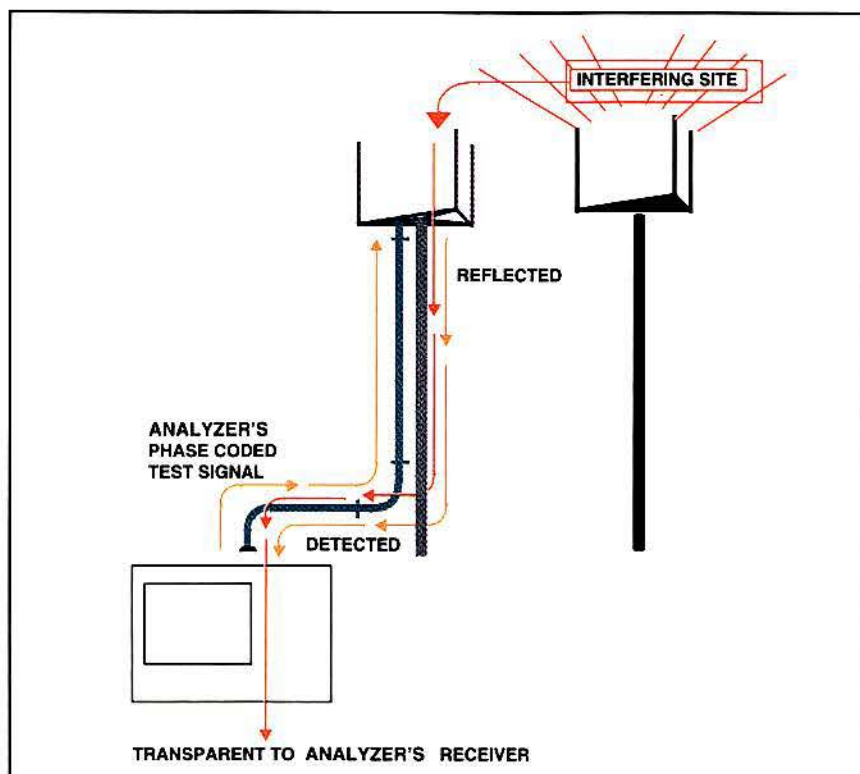


Figure 3: FDR techniques reject external RF interference at 'live sites.'

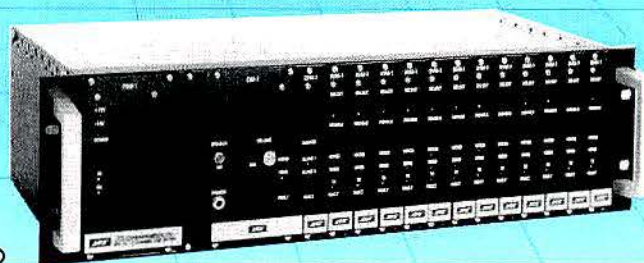
high winds. Because the antennas are coupled via a combination of front and back lobes, the isolation vs. frequency varies significantly with angular position variations, particularly with the higher isolation designs. Thus, these data can be used to indicate whether antennas have been moved or damaged without climbing the tower.

Seeing these sensitive variations is another convenient aspect of Site Master's internal design. Since bandwidths and averaging are automatically controlled, the measurements are repeatable. When using laboratory analyzers, each technician tends to set controls differently—reducing measurement repeatability. It is not that laboratory analyzers themselves lack repeatability; it is the way that they are operated that causes measurement-to-measurement differences. The FDR-based antenna system analyzer solves the repeatability problem; thus, mounting and damage conditions can be identified sooner—frequently before failures degrade signal quality.

RF interference

Unwanted RF interference affects both

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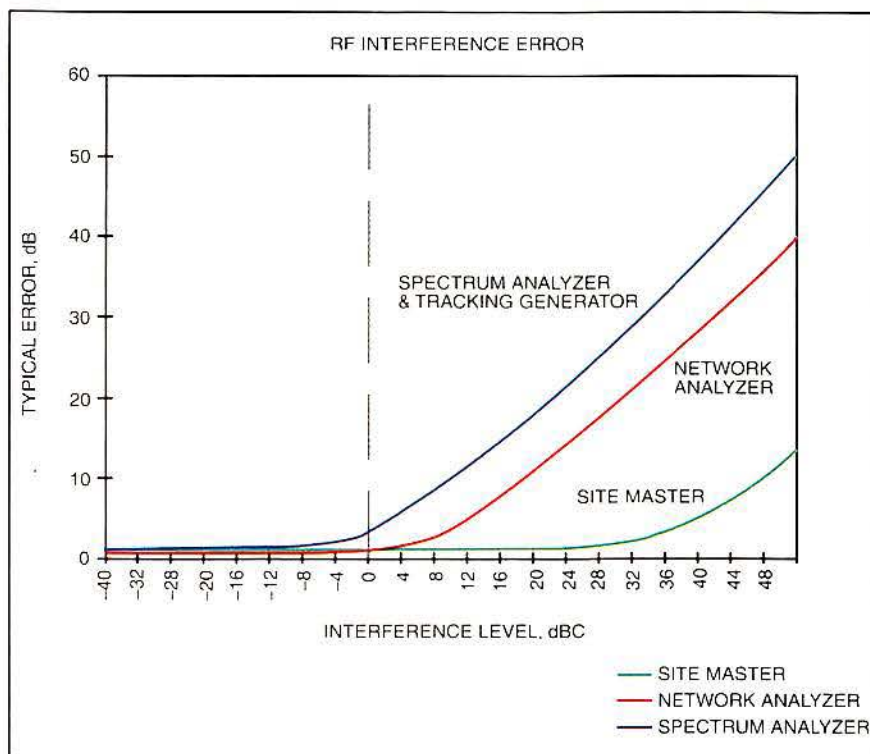


Figure 4. Typical error due to RF interference.

cellular signals and test signals. Unless the test instrument is designed to reject interference, the measurement will be corrupted. (See Figure 3 on page 18.) During both duplexer/LNA and antenna isolation tests, an antenna is part of the test signal injection path. Other RF signals are also received by the antenna.

One might assume that the only interference would be relatively low-powered transmissions from handsets, because local transmitters can be deactivated. That assumption is inappropriate for two reasons. First, complete site deactivation is undesirable due to system quality, cost and time-of-day restrictions. Second, other sources of in-band interference are common. For RF system design (such as the near-far handset reception problem), municipal zoning, and economic reasons, RF transmitter antennas are frequently co-located. Further, the explosion in wireless communications implies that the sources of RF interference will increase in the future, not decrease. If the test instrument lacks interference immunity, how can maintenance data be compared to baseline data?

Spectrum analyzers and tracking generator combinations are particularly sensitive to RF interference problems. A

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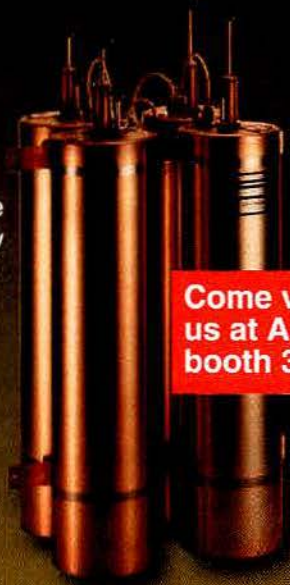
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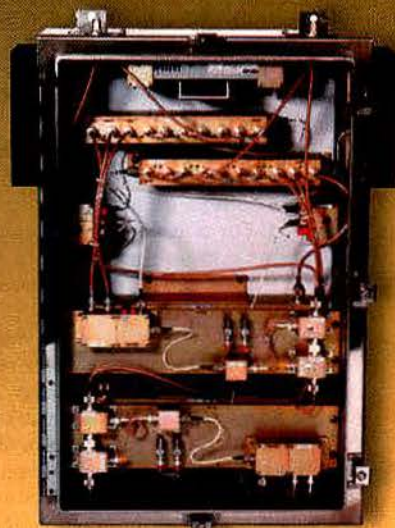
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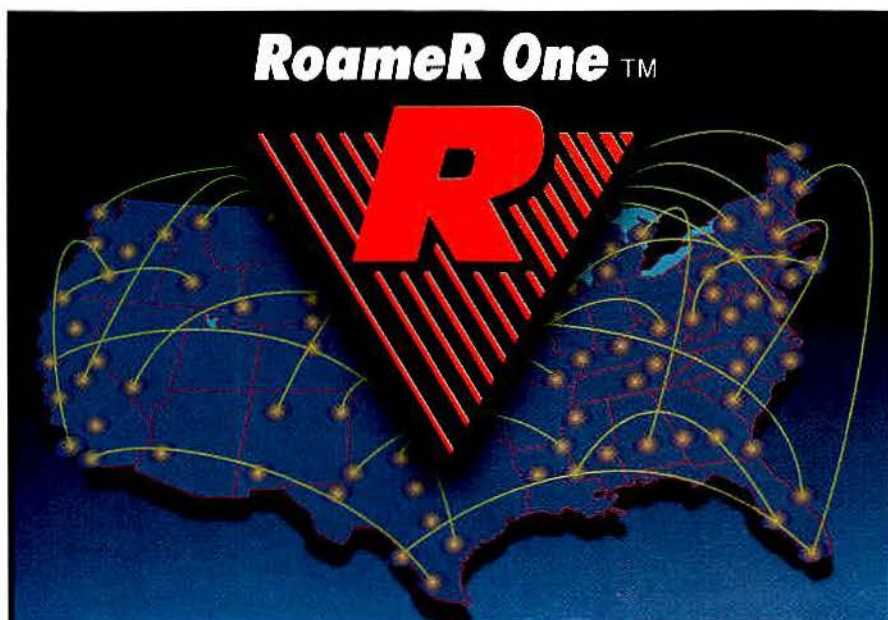


spectrum analyzer's receiver will measure any incidental in-band RF energy. Thus, interference is displayed additively with the test signal input from the tracking generator. As the interference power varies, so do the measured results. Further, since the antenna-to-antenna isolation is commonly high, the spectrum analyzer must be operated with its input attenuated to an operating range where the dynamic range is maximized. One can try to blast

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RF repeaters

RF interference also affects cellular signal performance. For example, the near-far problem has degraded service substantially for some digital services. Namely, a handset initiating a call to a far base station from a position near a competitor's base station has difficulty with call setup, particularly if the competitor's base station is analog.

Mini-cells have helped, but repeaters are likely to become another popular solution. In both cases, antenna isolation is important. For direct RF-to-RF repeating, the antenna mountings require high, >90dB, isolation. The antenna transmitting the repeated receiver signal is typically positioned on the opposite side of a building from the receiver antenna receiving traffic from the "far" handsets. Even though many repeater systems automatically back-off their transmit gain, should antenna isolation degrade, most engineers feel it is important to have verification test data during both installation and periodic maintenance intervals.

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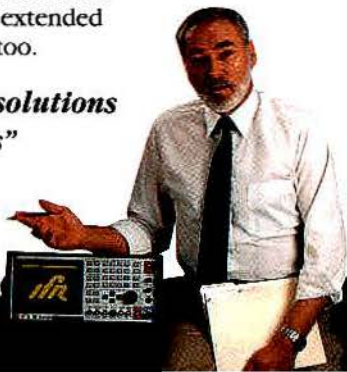
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The Cost of Quality

We all know that signal quality needs to be improved, but at what cost? Are airtime prices dropping? Yes, of course, but consumers are still prepared to pay a premium for top quality service. In an expanding market, both can be true simultaneously without adversely affecting profitability. Expanding network capacity creates simpler equation for operations managers. Unless subscribership increases sharply, as more cell sites are installed, cellular service operators must either a) shrink per-base station expenses or b) plan for lower earnings.

Rather than submit to the latter, managers are adopting *failure prevention* strategies. Historically, repairs are conducted on a *fix-after-failure* basis: antenna performance problems are allowed to degenerate into failures. Only after the failure does a site technician diagnose the problem.

Similarly, remote standing wave ratio (SWR) monitoring systems are available today that perform the same task. Problems are allowed to degrade until the SWR level is unacceptably

high, at which point an alarm is triggered. It is a case of false economy: In this case, the SWR alarm does not translate into preventive maintenance. Rather, it is a *failure* monitor. The antenna system SWR is monitored continuously, but it cannot predict, and thus, prevent, a failure. Well before the failure occurs, quality has been degraded. And, the failure still requires extensive equipment replacement.

The new maintenance paradigm seeks out the problems before expensive failures occur. Failure prevention simultaneously reduces service costs and improves quality. Because of the relatively high failure rate—due to weather exposure, poor-quality installation or both—RF cable and antenna testing is increasingly important.

For example, a loose connector may have a return loss of 12dB. But if it is at the top of the tower, loss in the antenna cable (say 4dB) will mask that value, making the 12dB failure look like 20dB ($12 + 2 \times 4$). A 12dB return loss (SWR, 1.7:1.0) will trip a SWR monitor alarm, but a 20dB return loss (SWR, 1.22:1.0) will not. If frequency domain reflectom-

etry (FDR) techniques are used, the loose connector is easily identified by distance-to-fault (DTF) analysis, and it can be tightened before moisture and corrosion destroy the expensive feed cable. So, what feeds have the most problems? Of course, the tallest, most expensive ones.

The key to preventive maintenance is quick recognition of small SWR changes within the antenna feed. The measurement task is accomplished by FDR. Recognizing changes is best implemented using DTF signature analysis. Because the FDR techniques are both sensitive and repeatable, new measurements can be directly compared to a database of baseline, or "signature" measurements. A graphic overlay comparison, such as found in the Anritsu Wiltron Site Master software tools, quickly identifies the minute SWR changes which precede failure conditions.

At least in antenna system maintenance, high quality doesn't equate to high maintenance. Good maintenance planning equates to good management.

—Ken Harvey

dynamic range, and of those achieving >90dB range, most require significant adjustment to reduce noise effects.

Analyzer performance factors

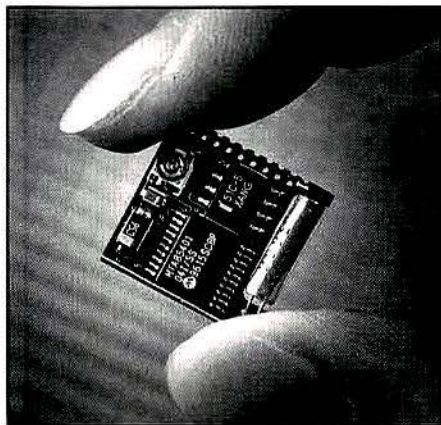
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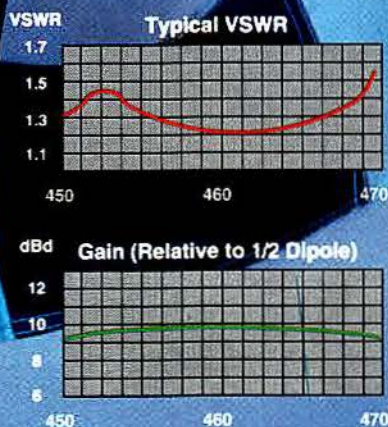
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IP linking creates new options and benefits for one-way paging

This base station linking method offers enhanced link bandwidth use, immediate fault reporting, instantaneous remote access to base station equipment and seamless link redundancy, all with the opportunity for cost savings.

By Dale Mortimer

The basic architecture of paging infrastructure has changed little during the past 20 years. At a central location, paging control terminals (PCTs) house the subscriber database, accept and process incoming calls from the telephone network, and encode pages for transmission. At distributed locations, radio transmitter and control equipment make up the paging base station. Pages are initiated by a call to the PCT. Pages are batched and encoded at a central location then transported via the "linking" system to the base stations. Finally, pages are sent out over

the air by the transmitters.

With the introduction of two-way narrowband personal communications service (NPCS), this model has changed somewhat. A network of receivers is now required to receive transmissions from the pagers. This new model prompted the use of a new communications links between the encoding site and the base stations. Two-way paging requires two-way communication between central locations and base stations. This is served best when using digital packet network-based links.

Packet network linking, also known as *IP (Internet protocol) linking*, is now also available for conventional one-way paging systems. Glenayre's GL-C2010 transmitter controller is equipped with IP linking interfaces, and it communicates with the encoder using the TCP/IP (transmission control protocol and Internet proto-

col) suite of protocols—hence the name, IP linking. This opens up a world of options for paging carriers and can provide increased flexibility, efficiency gains and cost reduction.

Paging systems linking

Traditional one-way linking, which carries paging data and, in some cases, configuration and control commands, is available in a number of forms, as shown in Figure 1 below. Broadcast wireless technologies, as well as point-to-multipoint terrestrial links, can be used. Broadcast technologies are typically either one-way satellite links or radio links. Terrestrial links include wireline links, microwave links or both. All of these options provide either digital or analog communications channels. Typically, each of these alternatives provides a

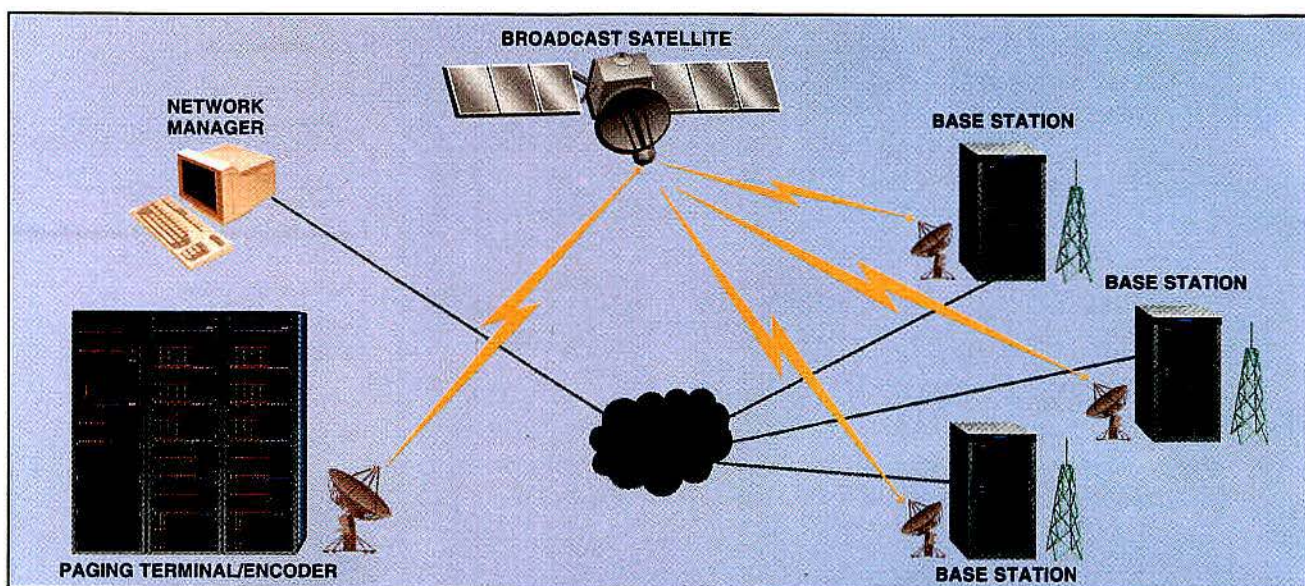


Figure 1. Traditional linking: paging data is transported to base stations via broadcast satellite. Configuration, maintenance and fault reporting are performed through a second communication channel, the Public Switched Telephone Network (PSTN).

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unidirectional data path, from the encoder to the base stations.

Critical to the operation of a modern paging network is the ability to change and to maintain equipment configuration, and for operators to be alerted of system faults, especially from remote base station sites. Consequently, there is a need to transfer information from the base stations to a central location where network management is performed. This can be accomplished by sending network management information out over the paging transmitter. Most often, however, in today's high-speed paging networks, this is done using a dial-up telephone line connected to equipment at each transmitter site. A connection with the public switched telephone network (PSTN) at the site permits both the base station equipment to automatically dial out to report faults and network operators to dial in to check equipment status and change configuration.

Using this architecture, two separate communications channels connect to the paging base station, which increases operating costs for the paging carrier. Another disadvantage of this design is that the forward channel links do not efficiently accommodate redundant links. If

an operator considers back-up links critical to business success, implementation may require additional equipment at the base station to manage the feature. Any solution will still incur the loss of paging data during switch-over time.

Dial-up links for fault reporting and base station access can be time-consuming.

Physically, packet networks can be switched or built on dedicated lines.

Establishing the link requires time, due to dialing and connection delays. If a base station dials in to report an alarm, it must complete the task and disconnect before an operator can dial back to investigate. Alarm reporting may be delayed if multiple base stations try to report at the same time. An operator can connect only to one base station at a time. These possible drawbacks can limit the paging carrier's

ability to deliver a maximum number of pages, a critical success factor of any paging carrier.

Packet networks

What exactly are packet networks? In packet networks, streams of digital data are split into blocks. These blocks of data are encased in framing and address information and injected into a transmission network for delivery to a specific destination or destinations.

Physically, packet networks can be switched or built on dedicated lines. A switched network is often a telecommunications network whose owner offers data delivery services. In a switched network, multiple paths will be between any external equipment serviced by the network, perhaps hundreds or thousands of paths. Under this topology, subsequent packets from a single source bound for the same destination may be switched through different paths. Public Frame Relay and X.25 networks are types of packet networks.

Private, dedicated lines can also be used to build a packet network. The lines can be duplex digital lines or dedicated analog lines equipped with modems at each end. The topology of the network

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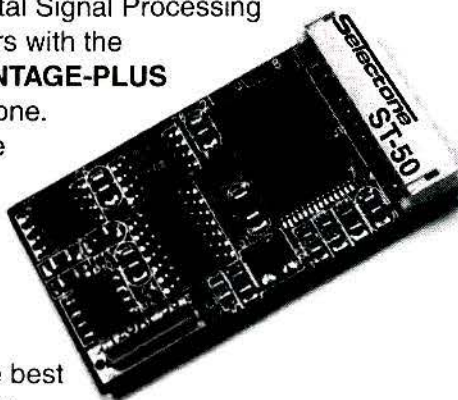
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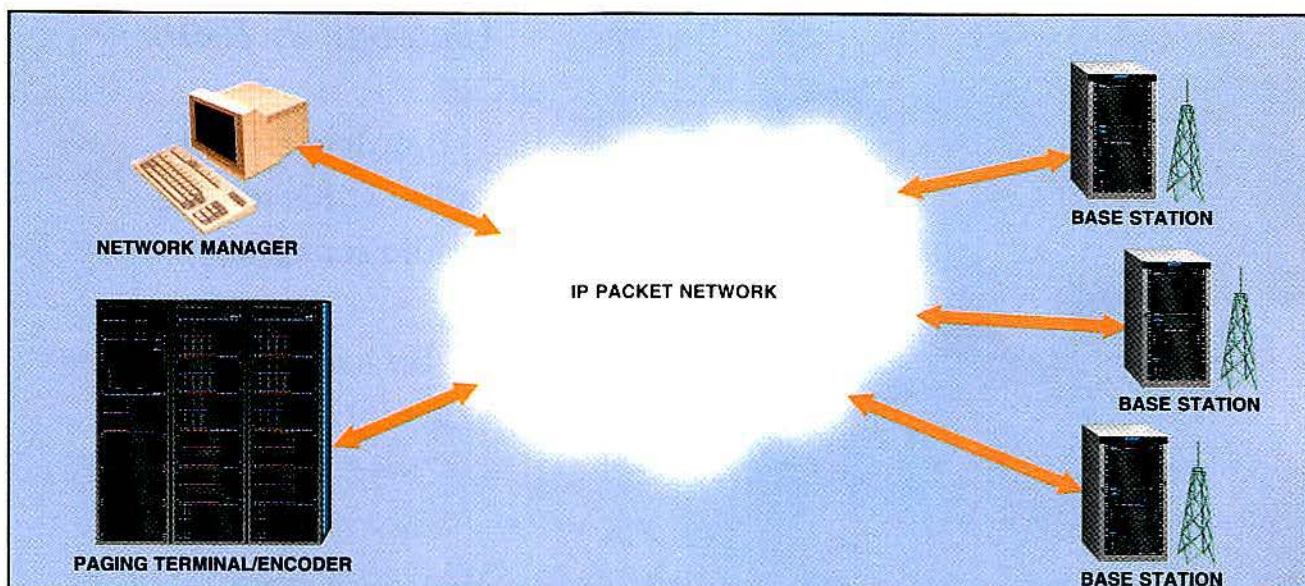


Figure 2. IP Linking: a common communications channel is used for all information transfer. The integrated network is represented by a cloud which, physically, has many possible implementations.

can be a ring, a bus, a star, a branched network or combinations of any of these.

A third, relatively new, example of a packet network is two-way VSAT (very small aperture terminal) satellite services.

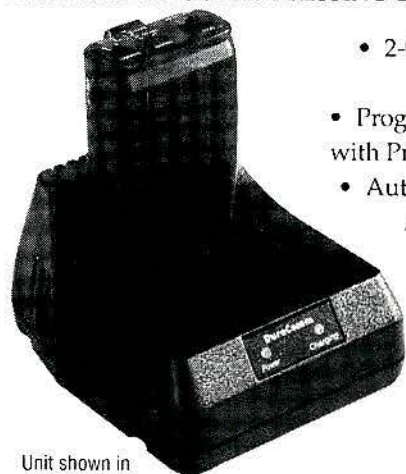
Vendors now offer this service, mixing data from numerous subscribers on the satellite carrier. Router equipment at each satellite receiver delivers forward channel data to appropriate customer equip-

ment. The reverse channel is managed using a CSMA/CD (carrier sense multiple access and collision detection) protocol, making the service essentially a big Ethernet in the sky. This is a bus topology;

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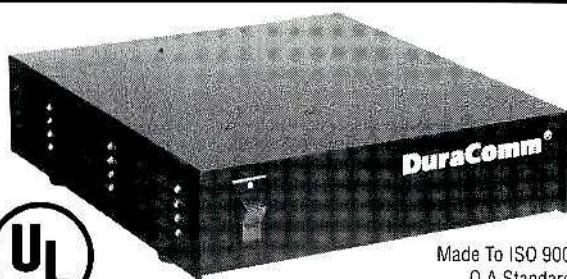
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logically, each terminal device is connected to the same data conductor.

One advantage of packet networks is the ability to connect separate networks of differing types using off-the-shelf equipment. Bridges, gateways, routers and switches manage the networks and facilitate interconnection.

IP linking and the transmitter controller

How can IP packet networks be used for

paging links, and what advantages do they offer? IP linking for paging systems provides a single integrated communications channel for paging data, fault reporting, configuration management and even equipment remote software upgrading, as shown in Figure 2 on page 30. The base station management connections are permanently established, and there is no congestion when multiple base stations report alarms. Alarms can even be reported to more than

one network management system, and with the click of a mouse button, an operator can instantly access any base station. In fact, network operators can have live access to many base stations at the same time.

IP linking with our transmitter controller facilitates efficient use of the paging links. This is especially true of paging networks that serve many separate simulcast regions using a private, dedicated line, IP links. Packets can be addressed and routed such that, in a branch topology, on any segment of the network, only those packets that are destined for base stations served by that segment will be transported; base stations will no longer receive data not intended for them.

Our controller also provides a duplicate packet option for seamless redundancy. When in this mode of operation,

IP linking for paging systems provides a single integrated communications channel for paging data, fault reporting, configuration management and even equipment remote software upgrading.

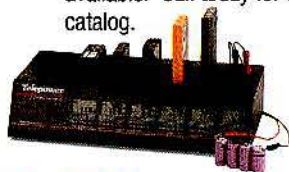
all paging data packets are sent out of the encoder twice. One of the duplicate packets can be routed through a primary network and the second through a completely separate back-up network. Both packets arrive at the base station and are routed to the transmitter controller. The controller is able to recognize the duplicate packets and discard one. If one of the packets is corrupted or lost due to problems on one network, the transmitter controller will use the received or uncorrupted packet. Imagine: a massive link failure without a single lost page at any base station!

All of these features of packet network linking increase efficiency of the paging system operation. Link bandwidth use is maximized, faults are reported immediately, problem rectification is carried out sooner, and seamless redundancy is available—all with the opportunity for cost savings. For paging carriers, these advantages provide increased reliability of page delivery, which translates into

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Markets

Packet network telecommunications is being deployed on a global basis at a phenomenal rate. The Internet, for example, is built on thousands of interconnected packet networks. With newer technologies such as ATM (asynchronous transfer mode) circuit-switched networks, today's telephone network is being replaced by packet networks where voice, video and data are seamlessly mixed into a single telecommunications network.

The availability and cost of public packet networks for use by paging operators vary significantly around the world. In regions with well-developed digital telecommunications infrastructure, public packet networks can be readily available and dedicated line private networks can be efficiently deployed. In other regions of the world, two-way VSAT is an available option and can be particularly well-suited for paging networks that cover a large geographic area.

A main benefit of packet networks is the ability to mix networks of different types within a single paging system. Urban areas may have readily available access to Frame Relay networks, whereas rural areas may not, although this does not present a problem for an IP-linked paging system. Urban base stations linked by Frame Relay can reside on the same virtual network as rural base stations linked using dedicated lines. IP linking will play a central role in the design and construction of new paging infrastructure on a global basis. For some paging operators, it is beneficial to swap-out their

existing control system and link methods and convert to an IP-linked system to take advantage of the efficiency gains, added reliability and cost savings. Operators with Glenayre's GL-C2000 controller, however, would require only an upgrade to realize the benefits of an IP-linked system.

The transmitter controller at work

The GL-C2010 controller is equipped with a 10Base2 Ethernet port and an X.21 WAN (wide-area network) port. At the data link layer and the network layer, the transmitter controller uses the TCP/IP suite of protocols. Paging data are sent from the encoding point to the base stations in a User Datagram Protocol (UDP) multicast format. On the same network, a TCP connection is used by network management equipment to communicate with any C2010 controller.

Already, paging operators at locations around the world are realizing the benefits of IP linking and the transmitter controller. A paging operator in the United Kingdom has implemented a private packet network on its own E1 links. By using infrastructure that connects the company's existing cellular telephone network, the marginal cost of the link network is low. At the same time, all the efficiency gains of the IP linking are realized. In the U.K. system, the transmitter controller connects to the network via its X.21 serial WAN port. Each base station is connected to a regional router using a single DS0 channel. Paging data branches out from the encoder site to regional routers, then on to the base stations. For this particular operator, this is a low-cost linking option that offers efficiency and

reliability gains.

PageMart Wireless, Dallas, is testing a paging network based on the transmitter controller using two-way VSAT satellite linking. In this case, an IP linking network will be available to serve both one-way and two-way paging. The initial requirement for the IP network is for the two-way paging system. With the transmitter controller, the separate link systems and PSTN connections for the one-way equipment can be eliminated at the co-located base stations. Again, the result will be cost savings and efficiency gains. Paging providers in the largest and fastest-growing paging markets in the world, North America, South America and Asia, are planning two-way NPCS paging. There will be strong incentives for operators to combine one-way and two-way linking networks.

A major role in future networks

Packet-network-linking systems are being deployed in many countries around the world. This type of paging system will play a major role in the design and construction of new paging networks and the modernization of existing ones. The need for this linking technology is being driven by several realities: increasing integration of one-way and two-way paging networks in North America; the importance of redundancy in Asia; and the growing demand from operators for more efficient, flexible and cost-effective networks. Expect to see the increasing use of IP linking in paging system design as more operators learn of the flexibility, conveniences and savings it offers.



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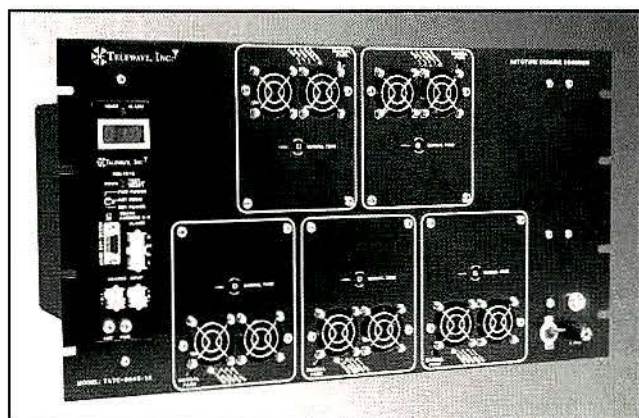
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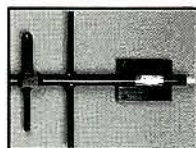
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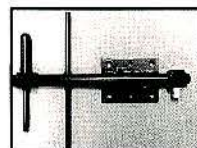
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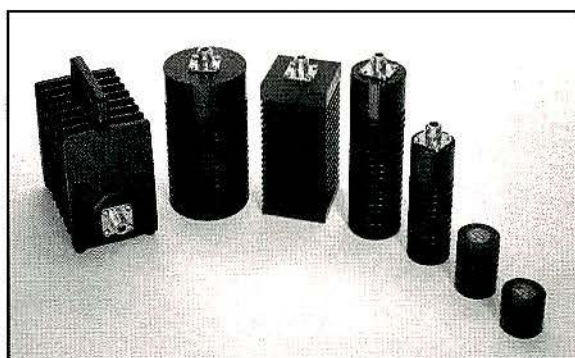
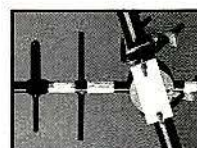
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Data acquisition in a conventional radio environment

Linking acquisition and computer hardware creates a record of activity, transmission lengths and airtime used in a conventional radio system.

By Mark Filla

Data acquisition in an 800MHz trunking environment is an easy task that is built into the system controllers, but for those of us in a conventional radio system, it could be an almost impossible task. Justification data to

add more conventional talk paths and more personnel takes a lot of work and, in some cases, is not practical because of the manpower and time involved.

I installed a computerized data acquisition system into the conventional radio network of the Palm Beach County Sheriff's Office. This stand-alone system has many applica-

tions. It logs into a data file the push-to-talks, minimum and maximum lengths of

Filla is radio system manager for the Palm Beach County Sheriff's office in Southeast Florida. He is GROL-licensed, amateur radio Extra class KS4VT and has an associate's degree in electronics technology.

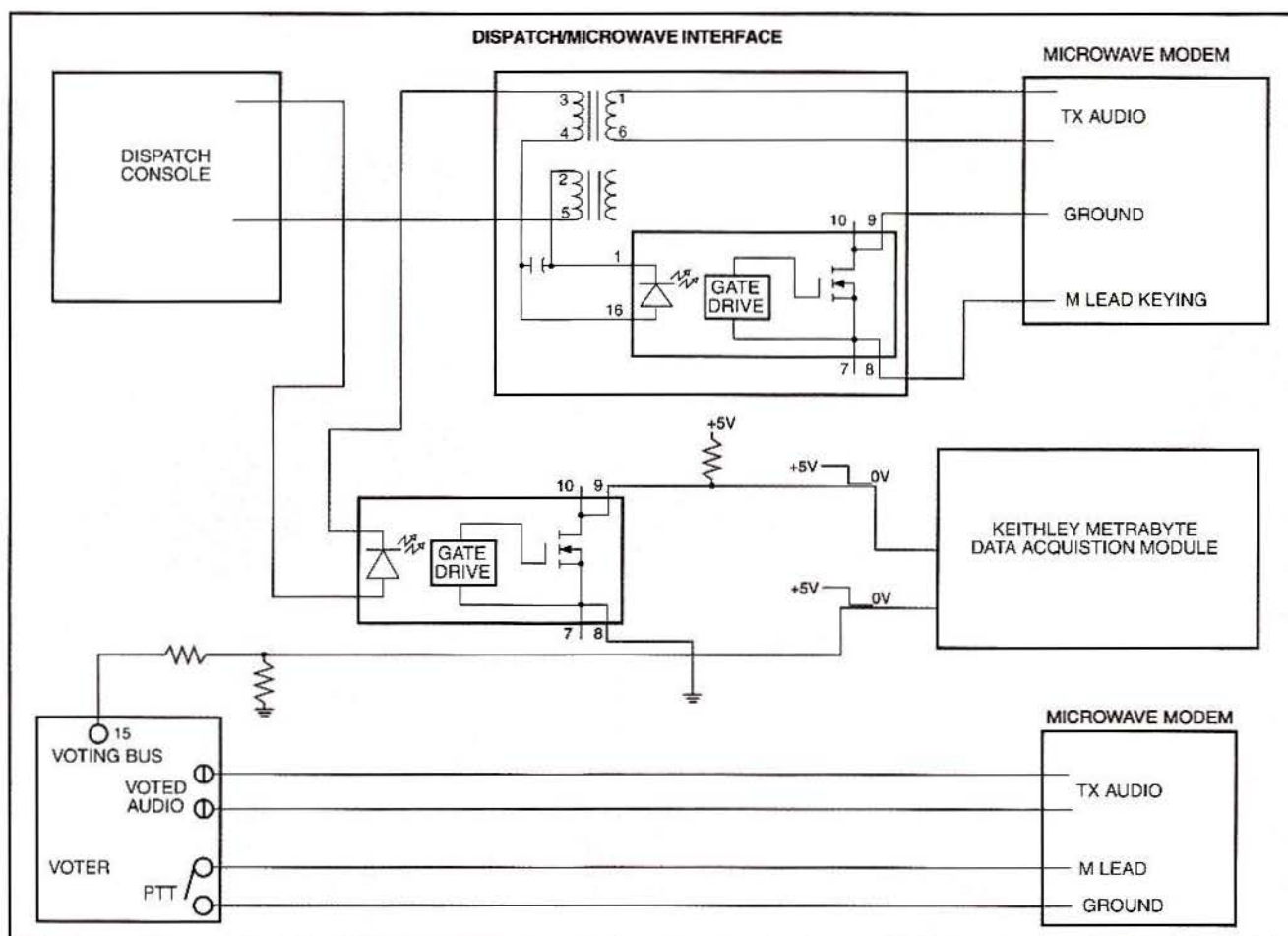


Figure 1. A schematic diagram of how the data acquisition module interfaces with the push-to-talk (PTT) of the receiver voter and the dispatch console.



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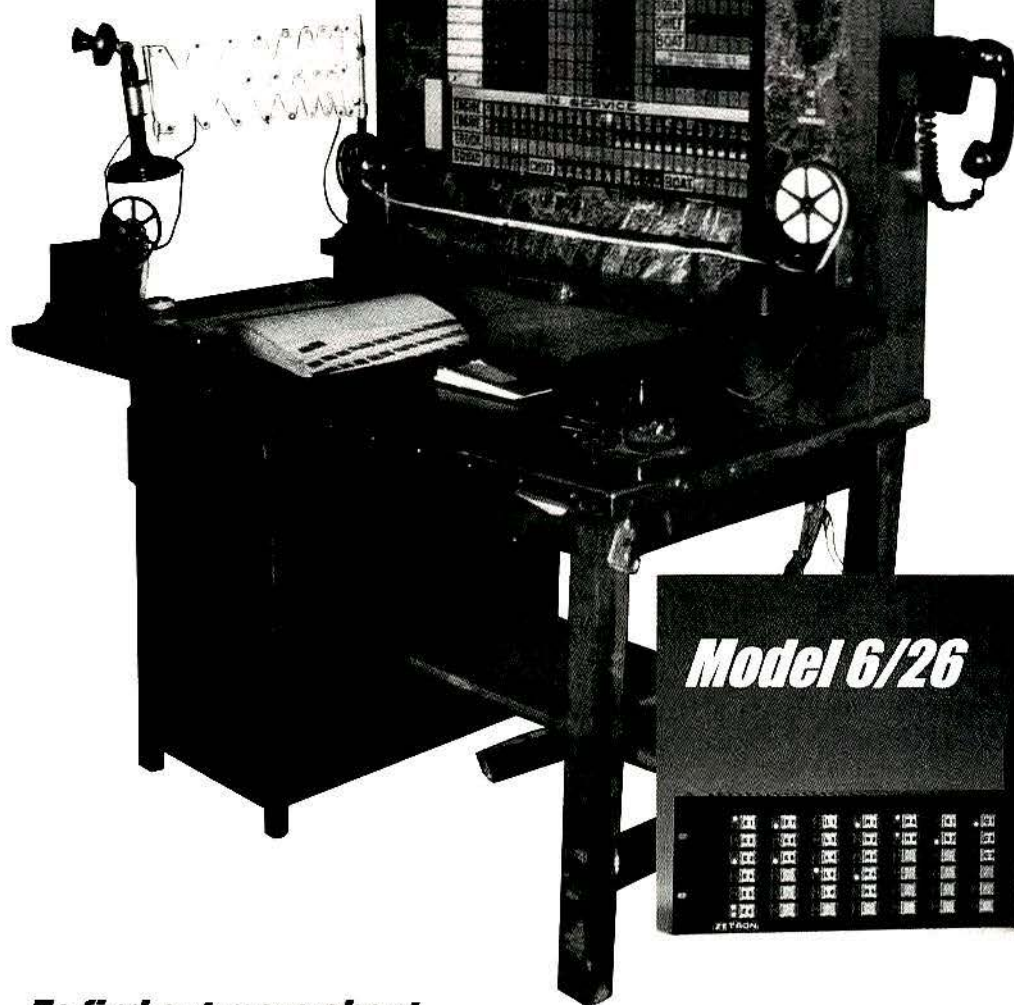
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Table 1. Radio usage monitor system - Daily report

Channel 1				Channel 2				Channel 4			
Time	Dispatch Dur. (min)	Voted Dur. (min)	Total	Time	Dispatch Dur. (min)	Voted Dur. (min)	Total	Time	Dispatch Dur. (min)	Voted Dur. (min)	Total
00:00	2.5	1.5	4.0	00:00	3.5	2.0	5.5	00:00	2.5	1.3	3.8
00:15	1.9	3.1	5.0	00:15	2.2	2.0	4.2	00:15	1.3	1.0	2.3
00:30	3.7	3.2	6.9	00:30	2.3	1.8	4.1	00:30	2.5	2.3	4.8
00:45	2.5	3.5	6.0	00:45	1.7	1.6	3.3	00:45	1.0	1.3	2.3
01:00	2.2	2.0	4.2	01:00	1.2	2.1	3.3	01:00	1.5	1.2	2.7
01:15	3.0	2.7	5.7	01:15	0.7	0.3	1.0	01:15	1.4	1.7	3.1
01:30	3.2	3.2	6.4	01:30	1.7	1.2	2.9	01:30	0.8	0.9	1.7
01:45	2.3	2.3	4.6	01:45	2.2	1.4	3.6	01:45	1.3	2.0	3.3
02:00	3.2	4.0	7.2	02:00	1.5	1.3	2.8	02:00	1.2	3.4	4.6
02:15	2.8	3.2	6.0	02:15	2.5	2.0	4.5	02:15	1.5	1.8	3.3
02:30	2.9	3.7	6.6	02:30	1.9	2.4	4.3	02:30	0.9	1.0	1.9
02:45	3.0	4.5	7.5	02:45	0.6	0.9	1.5	02:45	0.5	1.0	1.5
03:00	5.1	5.7	10.8	03:00	1.2	0.6	1.8	03:00	1.3	1.0	2.3
03:15	2.7	4.0	6.7	03:15	1.3	1.3	2.6	03:15	0.3	0.5	0.8
03:30	3.2	4.2	7.4	03:30	1.6	1.7	3.3	03:30	0.7	0.9	1.6
03:45	1.4	2.3	3.7	03:45	1.0	1.0	2.0	03:45	0.4	0.7	1.1
04:00	1.9	2.5	4.4	04:00	0.5	0.8	1.3	04:00	0.5	0.5	1.0
04:15	2.2	2.1	4.3	04:15	0.6	1.2	1.8	04:15	0.8	0.8	1.6
04:30	1.2	2.8	4.0	04:30	0.8	1.6	2.4	04:30	0.7	1.7	2.4
04:45	1.4	2.7	4.1	04:45	0.6	0.6	1.2	04:45	0.4	0.6	1.0
05:00	0.8	1.5	2.3	05:00	0.8	2.0	2.8	05:00	0.5	0.6	1.1
05:15	2.0	1.8	3.8	05:15	0.7	1.0	1.7	05:15	1.1	0.9	2.0
05:30	0.8	0.9	1.7	05:30	0.2	0.7	0.9	05:30	0.6	0.9	1.5
05:45	1.8	1.9	3.7	05:45	0.3	0.6	0.9	05:45	0.2	0.1	0.3
06:00	2.3	2.5	4.8	06:00	0.8	1.0	1.8	06:00	2.6	2.6	5.2
06:15	3.0	3.6	6.6	06:15	0.8	0.8	1.6	06:15	1.3	1.9	3.2
06:30	1.4	1.7	3.1	06:30	0.9	0.8	1.7	06:30	0.9	1.3	2.2
06:45	2.7	3.0	5.7	06:45	1.3	1.6	2.9	06:45	1.4	1.9	3.3
07:00	2.8	3.8	6.6	07:00	1.1	0.6	1.7	07:00	1.9	1.4	3.3
07:15	2.1	2.4	4.5	07:15	2.4	2.0	4.4	07:15	1.8	2.3	4.1
07:30	2.3	2.8	5.1	07:30	2.0	1.6	3.6	07:30	1.9	2.0	3.9
07:45	3.6	4.2	7.8	07:45	2.4	4.2	6.6	07:45	1.0	1.0	2.0
08:00	2.9	3.0	5.9	08:00	1.7	3.2	4.9	08:00	2.3	1.4	3.7
08:15	2.2	3.1	5.3	08:15	1.5	1.1	2.6	08:15	2.3	3.2	5.5
08:30	3.1	2.0	5.1	08:30	3.0	2.2	5.2	08:30	1.5	1.0	2.5
08:45	2.2	2.9	5.1	08:45	3.4	2.2	5.6	08:45	2.8	2.7	5.5
09:00	2.9	1.9	4.8	09:00	2.6	2.5	5.1	09:00	2.5	2.6	5.1
09:15	1.6	2.1	3.7	09:15	2.4	2.4	4.8	09:15	2.2	2.5	4.7
09:30	1.4	1.5	2.9	09:30	2.4	2.9	5.3	09:30	2.8	2.0	4.8
09:45	2.1	3.0	5.1	09:45	1.8	1.7	3.5	09:45	2.2	2.7	4.9
10:00	2.8	4.4	7.2	10:00	2.2	2.9	5.1	10:00	2.4	3.4	5.8
10:15	3.8	3.3	7.1	10:15	3.5	2.7	6.2	10:15	2.5	2.8	5.3
10:30	4.9	3.4	8.3	10:30	3.0	2.6	5.6	10:30	2.5	1.9	4.4
10:45	2.3	2.9	5.2	10:45	3.2	2.0	5.2	10:45	2.3	1.4	3.7
11:00	1.5	2.0	3.5	11:00	1.3	1.6	2.9	11:00	2.7	2.0	4.7
11:15	3.6	3.1	6.7	11:15	3.3	2.0	5.3	11:15	1.3	1.5	2.8
11:30	3.6	3.6	7.2	11:30	2.8	2.2	5.0	11:30	2.5	2.5	5.0
11:45	3.1	2.9	6.0	11:45	1.4	1.9	3.3	11:45	4.1	2.7	6.8
12:00	3.1	3.0	6.1	12:00	2.5	1.5	4.0	12:00	2.2	3.2	5.4
12:15	2.6	4.0	6.6	12:15	2.0	1.7	3.7	12:15	2.8	2.6	5.4
12:30	3.6	3.2	6.8	12:30	2.7	2.3	5.0	12:30	2.1	2.9	5.0
12:45	3.4	5.4	8.8	12:45	3.0	2.4	5.4	12:45	2.3	3.2	5.5
13:00	4.6	6.7	11.3	13:00	2.5	2.6	5.1	13:00	3.4	1.6	5.0
13:15	4.2	4.7	8.9	13:15	1.6	1.5	3.1	13:15	3.2	3.1	6.3
13:30	3.4	4.5	7.9	13:30	2.3	1.8	4.1	13:30	2.4	4.6	7.0
13:45	2.7	4.1	6.8	13:45	3.5	2.5	6.0	13:45	2.2	2.0	4.2
14:00	2.8	3.3	6.1	14:00	1.8	1.4	3.2	14:00	2.3	2.5	4.8
14:15	4.1	3.3	7.4	14:15	2.3	1.5	3.8	14:15	2.1	2.4	4.5
14:30	5.9	5.8	11.7	14:30	1.3	1.3	2.6	14:30	1.1	2.8	3.9

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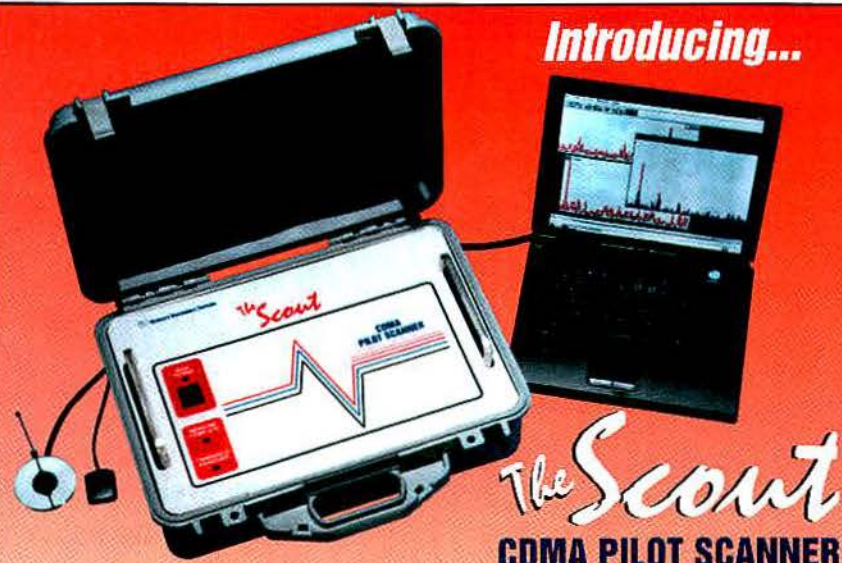
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the transmissions, and the total airtime used in both 15-minute and 60-minute intervals. This information is retrieved on a weekly basis and converted using Microsoft Excel spreadsheets to produce valuable data that is compared with computer-assisted dispatch-generated reports that show manpower statistics.

The acquisition hardware consists of a 486 PC running Windows 3.1 with a Keithley Metrabyte model 1202 16-port data acquisition module. The software was custom-written by Intech in Melbourne, FL, and consists of Visual Basic 4.0, combined with a custom graphical user interface and "Visual Test Extensions" VTX by Keithley Metrabyte. This package simplifies the process of data acquisition and custom report generation.

The tie points of the system required transitions from non-TTL levels to TTL levels for the module to accept. The high-voltage keying in the Motorola Centra-Com console in our application required the use of an opto-isolator and voltage pull-up resistors, which control an input channel on the data acquisition module. The voted bus line in the Motorola Spectra-TAC voter needed a voltage divider to bring the level down to +5V and 0V levels and then hooked to another input channel. These two applications were reproduced to sense five of our wide-area voice channels and our mobile data system. (See Fig. 1 on page 36.)

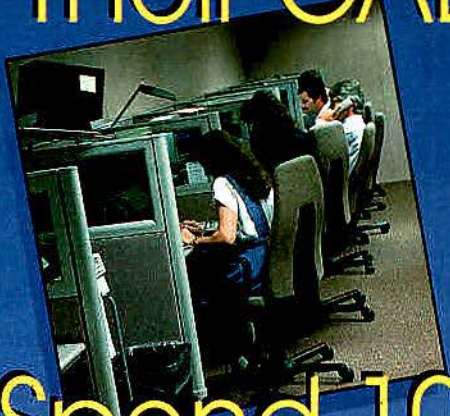
Installation options of this unit are versatile, depending on the type of system. I chose not to use it as an off-the-air unit. There is the possibility that erroneous data would be collected because of repeater hang time of other co-channel users, and there is the inability to separate the dispatcher and voted data. However, this is always an option to the system manager.

Captured data as of this time have shown the activity to be, on average, 40% to 45% on a normal day and then increasing to 90% to 95% during periods of high activity or a large number of users on the system. (See Table 1 on page 38.)

The Palm Beach County Sheriff's Office is a 36-site voted communication system spanning 2,200 square miles with seven wide-area repeaters in VHF and five local coverage systems. It is tied together by 12 hops of 6GHz microwave, five hops of 960MHz microwave and leased telephone circuits.



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	Cincinnati EMS	3312	ems	AV	
	Cincinnati EMS	3311	ems	AV	
	Cincinnati EMS	3310	ems	AV	
10000001	Cincinnati EMS	3309	ems	OD	
	Cincinnati EMS	3308	ems	AV	
	Cincinnati EMS	3307	ems	AV	
	Cincinnati EMS	3306	ems	NA	
	Cincinnati EMS	3305	ems	OD	
	Cincinnati EMS	3304	ems	OD	
	Cincinnati Fire	3303	ems	AV	
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'Mission possible': A low-cost alarm system for public safety 800MHz communications

Placing remote site alarms at a location that is continuously monitored can be accomplished without spending a great deal of money, adding bandwidth or increasing space requirements in the dispatch center.

By Carlton L. Tedrick, P.E.

The assignment is the needs assessment, preliminary design, and project management of a large public safety communications project. The system is a state-of-the-art 800MHz trunked simulcast network consisting of four sites that are interconnected with digital microwave. Additionally, a four-site, two-channel, conventional mobile data system

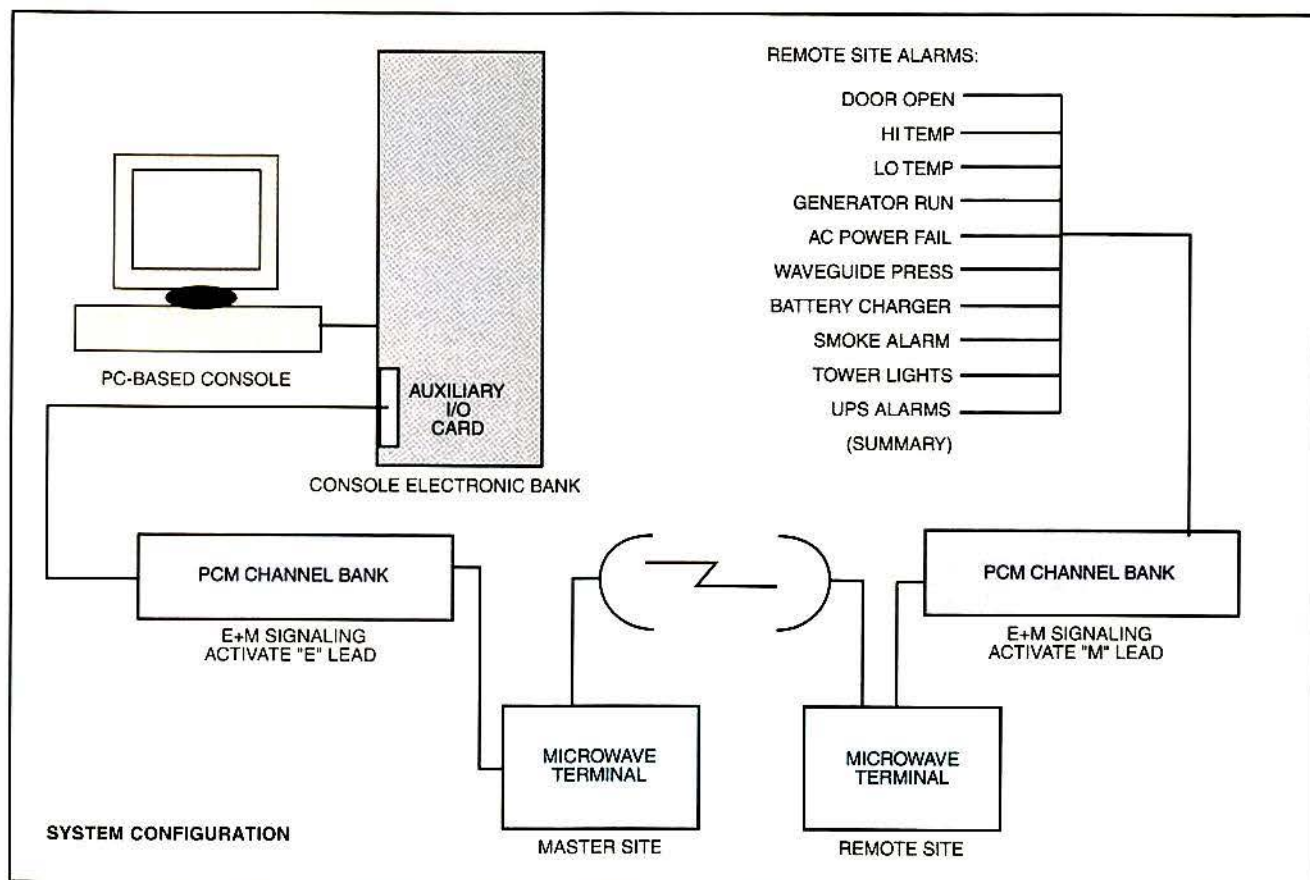
shares the same locations as the trunked voice system.

The challenges

The first hurdle that I cleared was getting remote site alarms to a location that was continuously monitored without spending a great deal of money. After checking with the popular alarm system suppliers, I found they were all relatively

expensive and required a certain amount of bandwidth to operate. These suppliers offered simple analog systems that would activate lights and sound audible alarms. There were also sophisticated software

Tedrick is president of CCI Telecom, El Paso TX, a privately held corporation, which provides telecommunications engineering and project management services. He is a member of the Radio Club of America.

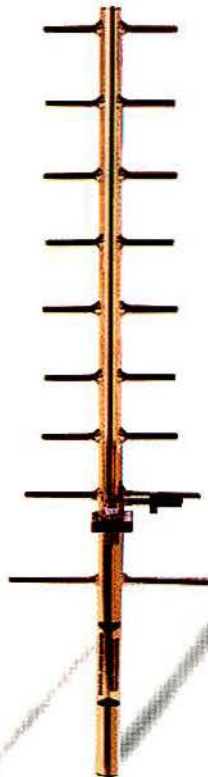


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driven arrangements that would report to a master computer, typically a PC. The computer would then generate an impressive multicolor display that a somewhat knowledgeable person would have to translate into action of some sort. Fine and dandy, but the obvious problems were:

- ❑ The alarm system would be an additional cost that was not in the budget.
- ❑ The alarm system would take up addi-

tional bandwidth that was not originally allocated for that purpose.

- ❑ Some of the alarm systems were not truly user-friendly.

❑ The display would be located on an already overcrowded dispatch supervisor's work location (CAD display, SIMS II display, CRT trunked radio dispatch display, and telephone panel).

Because the microwave was an all-digital system, I decided to try using the ex-

isting signaling capabilities of the network. The trunked simulcast radio system was supported by special channel modems (DSMs), and standard digital PCM channel banks supported the non-simulcast audio functions of the network.

Close examination revealed that the DSMs were fully used, in that even the "E" and "M" leads were used. The "E" and "M" leads provided a method of remotely switching a function from one end of the microwave link to the other. For example, a change of state of the "M" lead at one end of the link would cause a corresponding change of state of the "E" lead at the other end of the link. The good news was that the standard PCM channel banks did not use the "E" and "M" switching leads, and they were available for other duties.

Now, the remote site alarms that were of interest to me were:

- ❑ open door – intrusion
- ❑ high temperature
- ❑ smoke detector
- ❑ ac power failure
- ❑ generator run
- ❑ waveguide pressure
- ❑ tower lights
- ❑ battery charger failure
- ❑ low temperature

The solution

Each of these alarms could be configured to cause a form "C" contact closure upon detection of any of the above conditions. This was good! I could use the contact closure to cause activation of the desired "M" lead at the remote site. This was the beginning of the solution as I could now use existing "E" and "M" signaling to send remote site alarms without using up any additional channel bandwidth.

With this information now available at the microwave "hub," the next step was to display it at a location where a human could benefit from it. The reverse process was applied at the near end. For example, the door alarm contact closure at the remote end causes the "E" lead at the hub (near end) to change states (another switch closure). This was exactly what I was looking for. But now, what could we do with the contact closure? We could use it to light a light, sound a buzzer or maybe do something a little more informative that the lay person could use immediately.

When the new simulcast trunked system was installed, the existing console electronics bank was upgraded from conventional operation to trunked operation. This process left a lot of auxiliary input/output (AUX I/O) cards that were no

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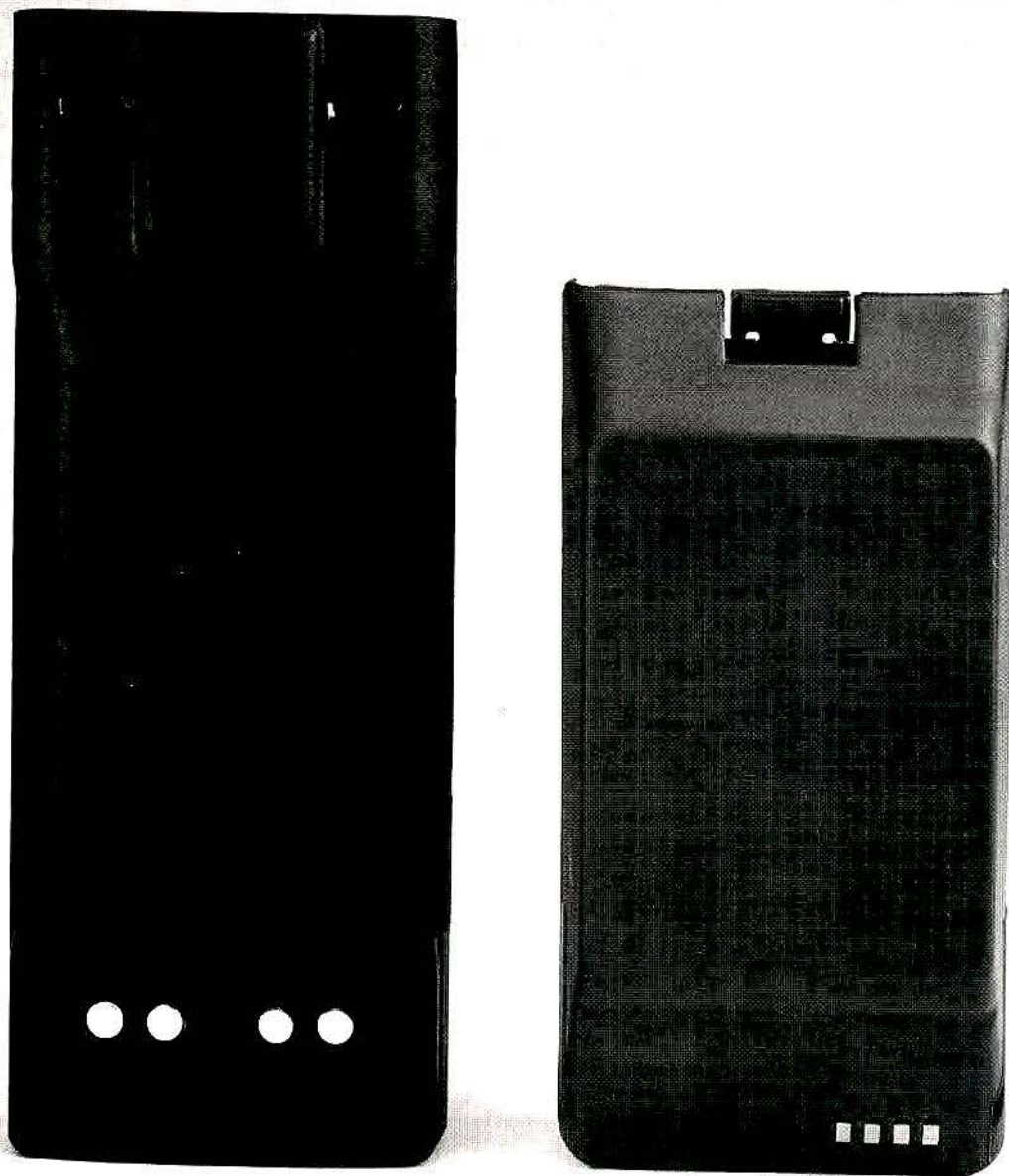
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longer in use. These cards would take a switch closure input and cause something to happen on the pre-programmed dispatch consoles. Now things were starting to get interesting! I could take a contact closure at a remote site and ultimately cause something to happen on a continuously monitored dispatch console.

The trunked system installation also included display-type consoles (expensive PCs). By having a Motorola field engi-

neer program the consoles properly, we could now have the remote switch closure (door alarm, for example) cause the console to beep and display "door open" at "site name." We even had the choice of a "momentary" or "latched" alarm. If we programmed the "door open" alarm to be a "latched" alarm, it would cause the console to stay in alarm even after the door was closed. In this case, the console operator would have to "clear" the door

alarm manually. This is desirable because a momentary door open alarm might be missed by a busy dispatch supervisor, allowing unauthorized personnel to quickly enter the site without detection. I also made the "ac power" alarm a "latched" alarm so that I could display and verify momentary power outages and fluctuations. All other alarms were designed to clear automatically when the alarm condition was corrected. To avoid additional work load on the busy dispatchers, only the dispatch supervisor consoles were equipped with the remote site alarm functions.

Successful operation

This system has been in place for more than two years, and it works well. The remote site alarm system design is simple, and it addresses the original four challenges:

- *The cost was minimal.* It required some technician time to wire in the alarm sensors and to make the connections from the channel banks to the central electronics bank that operates the consoles. It also required some of the Motorola field engineer's time to program the central electronics bank so that the appropriate consoles would display the desired messages.

- *No additional bandwidth was required,* such as using microwave channels specifically for this purpose. The "E" and "M" signaling was unused, so it was virtually "free" bandwidth.

- *The display is simple and user-friendly.* We have supplied a chart to each dispatch supervisor that prioritizes each alarm and recommends the course of action to be taken.

- *The display took no additional space* at the already overcrowded dispatch supervisor's work location. It was integrated into the existing dispatch screen.

As an added bonus, a failed microwave link is immediately noted, as all alarms start flashing at once. Of course, there are other indications as well, such as, no radio coverage in the area around the affected microwave site. (No shortage of people to report this problem!)

The only down side is that the microwave radio alarms are not available in this user-friendly and efficient format. Those alarms are "networked" so that they appear on the display of all microwave terminals (or repeaters) at each site. We still have to go to the microwave radio (typically at the "hub") to check for alarms. I will let you know when we figure out an inexpensive solution to that challenge.

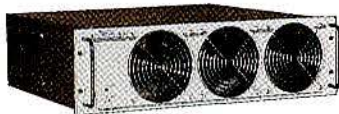


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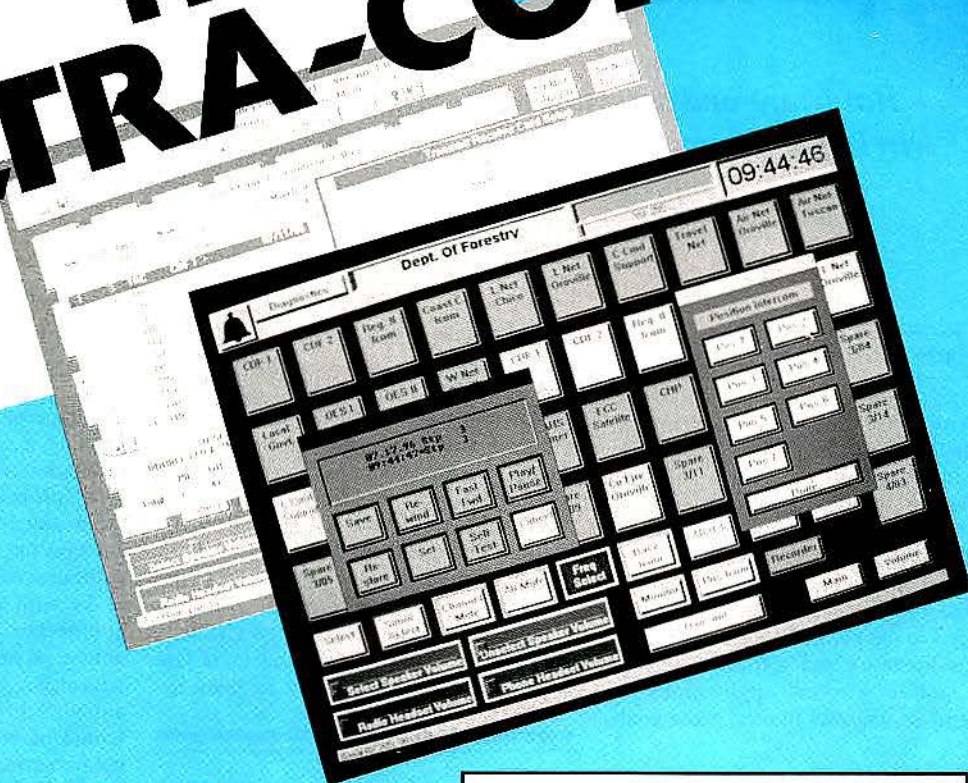
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Wireless use helps to meet public safety budget limits

Hardware and software technology improvements have allowed mobile wireless applications to emerge as a way for public safety organizations to improve service in spite of decreasing budgets.

By Mario DiCristofano

Because criminals are increasingly mobile, the need for more efficient services, increased officer safety and real-time access to criminal records has skyrocketed. At the same time, law enforcement budgets have been forced to include cost-effective approaches to improve service and enhance the level of safety provided to the public. With the evolution of new hardware and software technologies, mobile wireless applications are emerging as one way to meet these goals.

Early advancements

In the '70s, several pioneering law enforcement agencies turned to wireless communications to transmit up-to-date crime history to mobile patrol vehicles to increase the probability of removing criminal offenders from the streets.

Early wireless data technologies consisted primarily of message switches, computer-aided dispatch (CAD) and second radio systems that had been modified to send and receive only data. The systems were custom-designed and expensive to implement, but as they came online, they helped to form the foundation of future law enforcement systems.

Today's technology

Law enforcement agencies need improved methods for identifying and tracking highly mobile criminals on local, national and global scales in real time. The solutions offered today largely result from the integration of many networking standards and wireless technologies with software applications products

DiCristofano is director of state and local government business at MDSI Mobile Data Solutions, Chicago (Itasca), IL.

specifically designed for law enforcement.

The ability to have criminal histories and up-to-date information at the fingertips of the mobile officers is a key element of any integrated solution. Crime databases can be logically tied together and can allow law enforcement agencies at all levels to receive and transmit information among themselves.

An example of this trend is the FBI's continued development of the National Criminal Information Center (NCIC). NCIC gives federal, state and local law enforcement agencies a way to share in-

The ability to have criminal histories and up-to-date information at the fingertips of the mobile officers is a key element of any integrated solution.

formation. Interconnected databases have an advantage over central databases by spreading the cost among agencies, providing greater access controls by the departments supplying the information, and helping to minimize denial-of-service. Many government agencies such as the EPA and FBI are working together on information databases that will one day be interconnected. The same tools that will be connecting law enforcement agencies nationally can also be used on a global scale.

In other efforts to cut costs and improve service, many law enforcement agencies couple privately purchased wire-

less networks with public networks for data communications. Public networks can extend an agency's wireless coverage for less cost than either expanding or purchasing a new private network. Public networks can potentially cost less, and law enforcement agencies can benefit from any improvements to the system because the newest and fastest modes of communication will always be available.

As with all new technologies, these approaches have shortcomings. For example, private wireless networks have the advantages of confidentiality and control, although they sacrifice the cost-saving potential of public networks. Even though public networks cost less and cover large areas without the need for individual agencies to purchase dedicated communications equipment, public systems generally do not offer the level of access, performance and security that an agency may desire.

Law enforcement will see ever-increasing use of digital wireless communication technologies and lower costs in both the private and public networks. Digital communications will be used because the transfer of digital voice and data is more reliable than analog. Also, it can be encrypted more easily to provide higher security.

An integrated solution requires blending wireless technologies, networking standards and software applications specifically designed with law enforcement agencies' needs in mind. Many companies offer products such as workforce management (CAD), message switching and connectivity and mobile inquiry and reporting applications. Companies vary in the level of integration and services that they offer. Some provide integrated end-to-end solutions, and others provide only products or components that can be integrated as part of a total solution.

In the past, wireless data communications

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were hindered by cost, performance and the lack of integration. The technology choices available today are much more diverse and can be easily tailored to meet the goals of law enforcement agencies.

Future directions

Mobile computing has driven new innovations in wireless data networking, and it will continue to do so. Future tech-

nologies such as NCIC 2000 will integrate new functions and technologies by the addition of image processing such as mugshot, signature and identifying marks; the addition of automated single-finger fingerprint matching; the automation of some NCIC functions that are currently manually performed (e.g., validations, collection of data); the access to new databases (e.g., convicted person on supervised release); the addition of linkage

fields, providing the ability to associate multiple records with the same criminal or the same crime; and the access to external databases (e.g., the Canadian Police Information Center [CPIC] and the Federal Bureau of Prisons database).

Integrating wireless applications and systems with the functions that will be available through NCIC 2000 will get information to the officer in the car, make photographic images available and use single fingerprint technology for immediate positive identification. It will increase officer safety and reduce the risk of detaining the wrong individual.

Implementation of NCIC 2000 will require each state to update its law enforcement network—a major expense for states, as well as for many large cities and counties. Some states favor shared statewide systems to reduce the costs of implementing new technology. One example is the North Carolina State Highway Patrol (SHP). SHP, along with the state government, has created the Criminal Justice Information Network (CJIN). This wireless network is available for all state, city, county and local law enforcement agencies within the state to use.

Another example is the ALERTS network, which was created and is managed by the Illinois Criminal Justice Information Authority. It provides mobile data service to more than 200 law enforcement agencies in an 18-county area. In March 1995, the Illinois State Police formed a partnership with the authority to expand and enhance the ALERTS network. Since then, a number of other agencies, realizing the benefits the new network can provide, have joined the partnership and will be providing funding for Phase I of the project. The goal of this cooperative, three-phase project is to upgrade the existing system so that it is a statewide, high-speed network capable of transmitting images and meeting state and local agencies' mobile data needs.

Current and future technologies offer more options for deployment than did previous technologies and can provide fully integrated capabilities to send and receive data anywhere at any time. As new hardware and software technologies continue to advance, the use of mobile wireless applications will become more widespread among public safety agencies. Mobile wireless applications are already proving to be an efficient and effective means for providing law enforcement and other public officials with real-time access to information. In the future, mobile wireless may well become the preferred approach to cost-effective information exchange.



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Approaching the unknown: The 800MHz system management position

Oversight of the implementation and operation of an 800MHz trunked radio system requires an adept, 'on-site' person who is both familiar with the hardware and capable of administrative tasks.

Frederick G. Griffin, P.E.

Making the transition from a small system to an 800MHz trunked system can be intimidating. Certain measures should be taken when upgrading a communications system, including taking on a qualified system manager.

As our population grows and as emergency operations become more complex, public safety organizations must upgrade their communication systems to serve more users. The radio spectrum is limited, and this has led to the use of trunked radio systems. These computer-controlled radio systems allow numerous departments to share and converse on one common system. The increased operational complexity of such systems requires the establishment of a new position: systems manager.

Life was simpler with conventional systems composed of building blocks where errors or changes could be easily made. The investment in conventional systems was small. Life is no longer simple. The trunked systems are extensive and complex, and the investment is embedded. With an embedded investment, planning and management are key. The complex radio systems have now taken on the characteristics of utilities. Utilities need system managers.

Manager duties and responsibilities

1. The system manager is the "on-site"

Griffin is president of Frederick G. Griffin, P.C., a nationwide consulting firm in Lynchburg, VA. He is a member of APCO, NENA, the Radio Club of America and past president of the Association of Federal Communications Consulting Engineers.

person who manages the system. He stays abreast of the implementation activities and decisions made from the beginning of the project.

2. Until equipment arrives, the system manager prepares for the radio programming and training sessions. The system manager follows the project's progress with regular monthly meetings.

3. The system manager coordinates and monitors equipment installation.

4. The system manager's position may

*As our population grows
and as emergency
operations become more
complex, public safety
organizations must
upgrade their
communication systems
to serve more users.*

or may not be full-time. Other responsibilities may be added to the system manager's duties.

5. The radio system requires continuous database management, mainly upgrading radio ID numbers. These numbers coordinate the individuals with the radios. When the radio is in use, the numbers appear on the dispatcher's screen and on the screen of the radio. This feature is particularly important in the case of an emergency alert. If the database is not correct, the emergency alert will fail as a

result of inaccuracies. Database errors are a result of people changing jobs and keeping the same radio or trading radios. Correcting the errors adds to this already time-consuming activity. The more radios on the system, the more time-consuming the system manager's job becomes.

6. Achieving a high-system state of readiness is critical. The system manager ensures that preventive maintenance is performed and manages the maintenance database. The system manager is responsible for visually surveying the system's antenna sites. Tower anchors must be monitored for corrosion. Corrosion and deterioration increase with depth. Slight surface deterioration should be viewed as a serious omen.

7. Some of the auxiliary responsibilities and duties that may be included in the system manager's position are:

- ☐ orienting new hires about using the system.
- ☐ antenna site rental to others.
- ☐ landlord relations.
- ☐ FCC and FAA liaison and keeping licensing current.

8. Depending on the configuration of the system, routine inspection and testing of in-building enhancers or tunnel systems may be required. Building enhancers are free-standing subsystems that allow radio waves to be retransmitted inside structures or shielded areas. Typically, enhancers do not have self-diagnostic, alarm or self-monitoring functions; therefore, they need to be verified periodically to ensure the security of tunnel systems and transmission lines.

9. One of the greatest challenges in an 800MHz system is fleet mapping (initial and update). Fleet mapping involves assigning radio talkgroups to departments, giving or denying access to other

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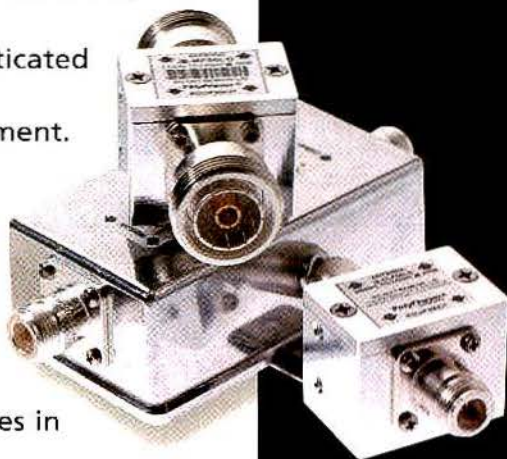
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department's radio groups. No matter how well someone understands any organization and operation, fleet mapping is difficult and most often is not completed on the first try. In most cases it takes three or four adjustments to complete a system map. System mapping has to be customized for each system. The system manager acts as the teacher, tutor and landlord to each department head. Each department must determine who is in each talkgroup and who,

outside the talkgroup, has access to it.

10. Serving as the mutual aid coordinator (communicator with neighboring jurisdictions) is part of the system manager's job. The task includes being the liaison and facilitator with all of the neighboring or even non-neighboring jurisdictions. When a rescue unit enters a neighboring jurisdiction, mutual aid or resource agreements allow for that unit to temporarily transfer to the management

of the neighboring jurisdiction.

11. The system manager communicates with local administrators to keep abreast of changing concerns.

Personnel profile requirements

The system manager's position is a hybrid, requiring a person who is organized, motivated and able to work with hardware, technical, computer and administrative aspects. By its very nature, the job has diverse duties. The position requires experience or awareness in several key areas. Technical training, user training, dispatcher supervision and administrative experience are beneficial but not critical. The candidate must be flexible. A successful candidate does not necessarily have to fulfill all of these criteria but should have experience in at least some of these areas and be willing to learn new skills.

Implementation

Trunked system implementation is typically a phased process:

- Phase One: needs, requirements and alternates—laymen's report.
- Phase One A: decisions and funding direction given.
- Phase Two: procurement—signed vendor contract.
- Phase Three: implementation—substantial use and possession.
- Phase Four: claims resolution and warrantee monitoring.

Signed contracts for these systems typically are executed without either party being truly in a position to perform. This dictates the need for a Notice-to-Proceed clause. It is in this period that site access, FAA approval and FCC licensing are obtained and workers are assigned to the project.

Once all licenses and approvals are in place, the vendor and buyer are ready to implement the Notice-to-Proceed clause, giving permission to start the project. At this time, the system manager should be assigned.

After the Notice-to-Proceed clause is signed, the system manager is needed for project management, employee training, acting as a liaison and a mutual aid coordinator as well as completing routine inspections. The system manager has many responsibilities; however, the scope and complexity may vary, depending on the size of the system and the needs of the jurisdiction.

With preparation and a dedicated system manager, the transition to a new radio system can be a smooth, enjoyable experience.



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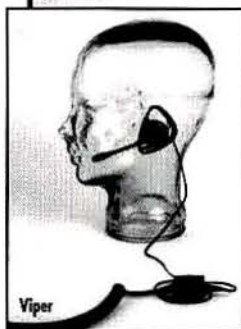
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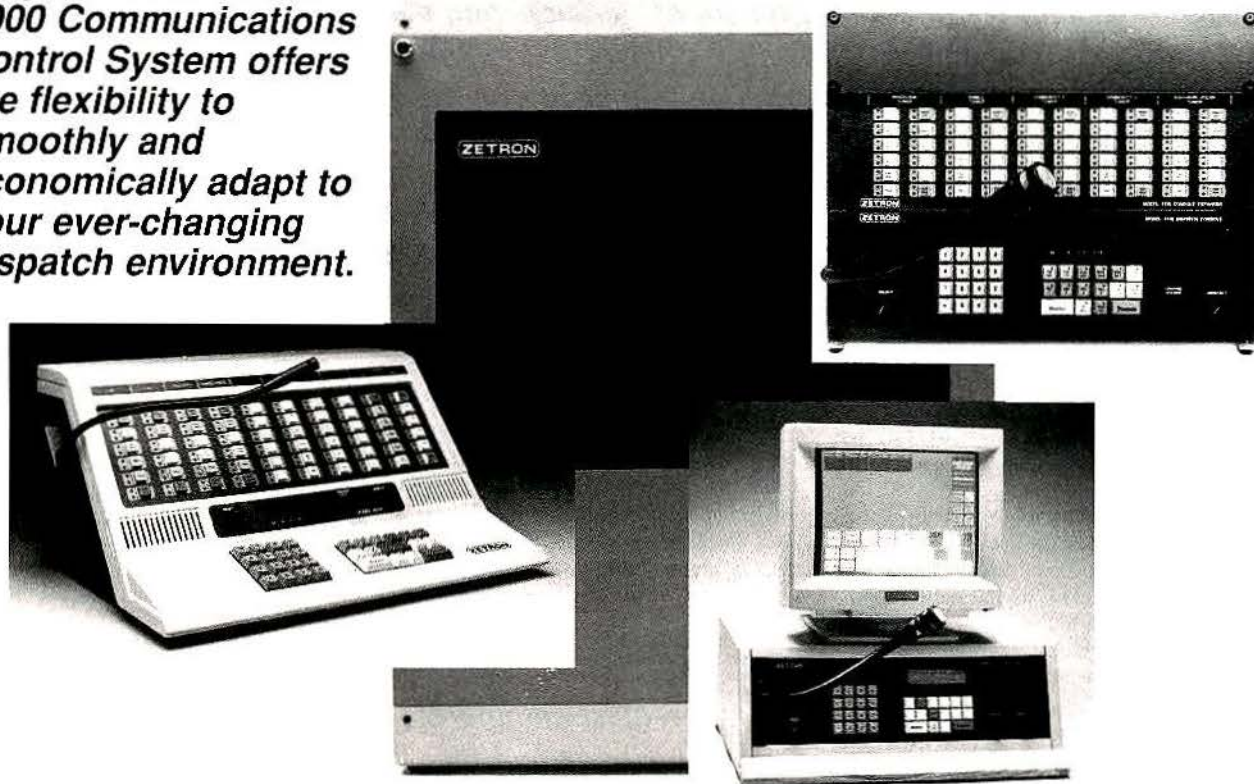
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Digital shapes the future for land mobile radio

Digital technology affects the functions, features and maintenance techniques for land mobile radio equipment, especially specialized mobile radio (SMR). Technicians are spending more time optimizing entire radio systems.

By Malcolm Oliphant

Land mobile radio continues to borrow features and technology from the cellular industry. As with cellular, radios in land mobile service use a growing number of digital functions that defy traditional trouble analysis and feature a growing list of maintenance aids.

Trends in land mobile radio testing and new radio techniques are bringing about changes in the test equipment market. The rush to adopt various digital radio proposals will usher in a new wave of powerful and reliable self-test features and self-optimizing networks.

Land mobile radio—it's not cellular

Considering the growing dominance of trunked radio techniques used in the land mobile industry, especially SMR (specialized mobile radio) systems that increasingly dominate land mobile services, it might seem that cellular radio techniques and systems eventually will replace even the most modern SMR systems. Although there may be some slight truth to this assumption, fundamental differences between cellular and SMR systems, particularly in the way they are used, will continue to drive the need for each market. Basic variations between the two technologies include:

1. *PSTN access:* A cellular system's primary goal is to provide a mobile link to the PSTN (public switched telephone network). Although SMRs also can make mobile connections to the PSTN, it is not their primary job.

2. *Open channel:* An SMR user or customer prefers and expects open channel working through the universal PTT (push-to-talk) switch. Access times of less than

one-tenth of a second are common in modern SMRs.

3. *Back-to-back:* SMR terminals most often are used in back-to-back working situations through a repeater. This practice is unusual in cellular systems.

4. *User partitioning:* The familiar channel selector knob on the typical SMR radio is the primary instrument through which users are partitioned among themselves on the system.

5. *User statistics:* SMR users access their systems more often than cellular phone users access their cellular systems.

The greatest amount of similarity among the service entities—cellular and land mobile—is seen in the service shop.

The cellular radio connection is full-duplex—lasting several minutes—and the frequency of the connections established during the day is typical of that with normal desk phone use. The SMR user gains access to the system hundreds of times each day, and the connections last only a few seconds.

6. *Dispatch:* SMR systems can be configured so that any terminal or dispatch console can simultaneously establish communications with many radios.

7. *Coverage:* One goal in typical SMR system design is to maximize system coverage, usually from a repeater site in some ideal location. Cellular systems have an opposite goal, which is to maximize the system's capacity or the number of

phones that can be connected to the PSTN at the same time.

8. *Terminals:* SMR users, particularly in demanding public safety applications, generally require highly specialized terminals within a wide range of hostile operating conditions.

9. *Data:* Cellular traffic is dominated completely by full-duplex voice. SMR systems carry a much broader mix of voice and data than cellular systems.

Examples 2-7 can be simulated in modern digital cellular systems through the use of packet radio techniques, but usually at the expense of the cellular system's capacity. The more closely the SMR feature set is simulated in a host cellular system, the more the system's capacity for its PSTN connection traffic suffers.

Digital radio and modulation

Digital cellular systems are popular among the mobile phone network operators because they can multiply the traffic that a physical channel, such as a 30kHz channel, can carry. They perform the multiplication through a variety of radio access techniques. The enabling technology for all of the access techniques is digital modulation, which reduces the information in the radio channel to symbols. These symbols are generated in the transmitter's digital modulator in accordance with a set of instructions from the baseband part of the transmitter.

The instructions are bit patterns that represent the information coded into the symbols. The symbols are recovered in a receiver that demodulates the transmitter's manipulations of its carrier and passes the demodulated waveform on to a decision circuit that decides which of the symbols the transmitter sent at any instant.

SMR systems have followed cellular into the wide adoption of digital radio techniques, but with some minor, though significant, differences. One of the

Oliphant is director of training for IFR Systems, Wichita, KS.

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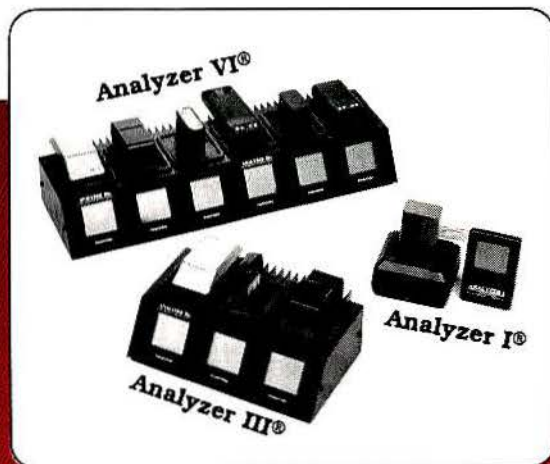


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variances is in the preferred modulation types. Because land mobile systems tend to have many operation modes and sometimes need to interwork with analog systems, they tend to avoid some of the complex in-phase and quadrature (I/Q) modulation types used in certain digital cellular radios. This linear modulation simplifies amplifier and system design. Another difference is in the use of access techniques. Land mobile systems use various

radio access techniques to enhance system performance, such as access time, rather than to optimize system capacity. For public safety service users, this is significant because of their preference of system performance characteristics over capacity.

Testing digital radios

Aside from the numerous technical advantages inherent in digital modulation,

such as resisting noise and enabling new radio access techniques, digital modulation removes the possibility of analog signals anywhere in the radio except at the microphone and speaker. This greatly simplifies radio testing and maintenance. The greatest similarity among the service entities—cellular and land mobile—is seen in the service shop, where fully digital radios are serviced with digital testing technologies.

Digital radios have two analog interfaces: the audio interface (speaker and microphone); and the RF (radio frequency) interface at the antenna (transmitter output and receiver input). These analog elements notwithstanding, everything between the audio and the antenna is digital.

► **Digital transmitters:** A digital modulator imparts information to an assigned carrier by adjusting the carrier's power, phase or frequency among a small dictionary of possibilities. Because there is no amount involved with digital modulation,

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Many types of channel coding schemes exist, some more powerful than others.

no adjustments are generally required in the modulation path. Instead, it is usually sufficient to examine the quality of the modulation, or how good the modulator is at making its adjustments to the carrier. This parameter is measured in a percentage, or some other quality score against a goal. When the goal is not met, one looks for a defective component that is causing the problem.

An important example is the transmitter path, which ranges from the RF to the power amplifier, including the antenna. Anything beyond the digital modulator can add its own distortions to the modulation. Some of the devices may be linear, such as feedlines and antennas, and some, such as amplifiers, may not. Informed substitution, tempered by knowledge of how a device could distort a digital modulator's output, is enough to clear low-quality (high-error) readings of the modulation somewhere in the transmit path. A radio test set with some kind of modulation domain display applicable to the modulation under consideration is helpful in transmit path analysis.

► **Digital receivers:** Except for their

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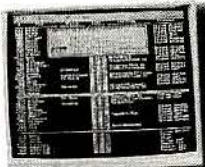
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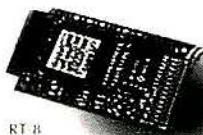
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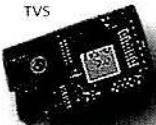
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Circle (56) on Fast Fact Card

decision circuit, digital receivers are remarkably similar to their analog cousins. Their differences occur in the manner in which they are tested. In the case of analog, the SINAD (signal-to-noise and distortion) procedure is efficient because it tests the whole receiver path in one pass. As part of the SINAD procedure, a low-level carrier is inserted, modulated in a manner appropriate to the demodulator under test, at a known rate, such as FM at 1kHz.

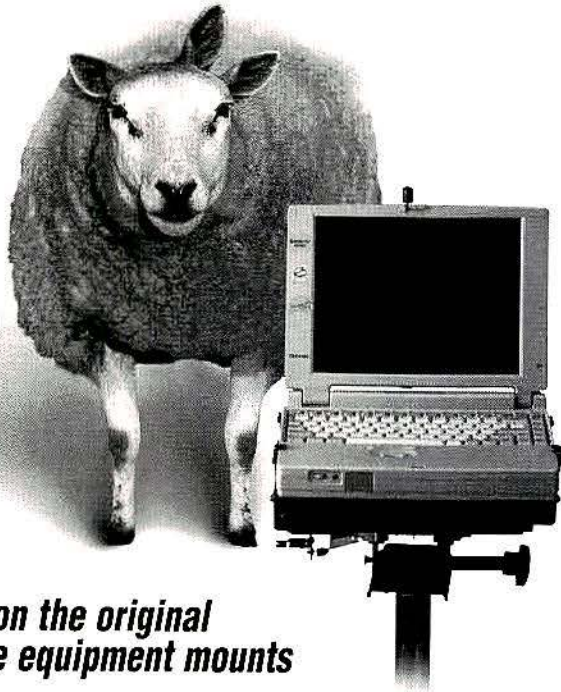
The audio output of the receiver is examined to separate the original test tone (1kHz) from any distortion and noise that the receiver added to the original test signal. The ratio of the two separated signals can be equated to some test threshold. The receiver's circuitry can be manipulated to optimize the ratio so that the distortion and noise portion are minimized.

The procedure applied to a digital receiver is functionally the same. However,

the absence of a 1kHz tone has to be accounted for to take advantage of the presence of symbols on the test signal. The RF test source is modulated in a manner appropriate to the demodulator under test, such as 4-level FM: frequency shift keying between four frequencies instead of two (4FSK). The symbols emerging from the receiver's decision circuit are compared with the symbol stream used to modulate the test source.

Depending on how channel coding is performed, generated and recovered symbols can be compared on a per-symbol basis (BER), or comparisons can be made on blocks or frames of symbols (FER). The BER (bit error rate) expresses a ratio of the total number of decision opportunities presented to the receiver (from the test generator), relative to the corresponding number of wrong decisions made by the receiver. A BER rating of 0.20 is an indication of a better receiver than a BER rating of 1.20.

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*Channel coding, a
baseband process used in
most digital radio systems,
deliberately adds carefully
contrived redundancy to a
symbol stream.*

Channel coding, a baseband process used in most digital radio systems, deliberately adds carefully contrived redundancy to a symbol stream. The receiver uses these extra symbols, or bits, to repair damaged data streams from the transmitter. As a result, radios that protect all of the user traffic with redundancy bits, which are also encoded into symbols, lose the ability to detect individual bit errors. Instead, the frames or blocks of bits (symbols) that cannot be repaired are marked by the receiver as having suffered an error. An FER of 0.10 is worse than an FER of 0.00. The second result indicates no frames were received with uncorrected errors.

Baseband processes

In place of various audio processing circuits found in analog radios, digital radios perform numerous bit manipulations that do not require testing or adjustments of any kind. One reason digital radio has become so popular is because of the reduced maintenance represented. The

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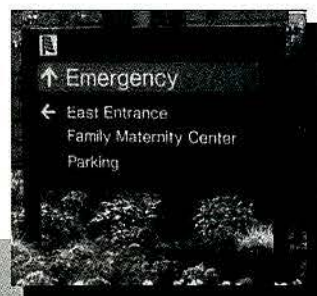
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digital domain processes, collectively called baseband processes, include:

► **Channel coding:** Gain can be added to a digital radio system by encoding and scrambling traffic data (voice data or computer files) in some clever way known to the receiver. The receiver can "figure out" what the original data or symbol stream actually was, even in the presence of a high BER (a high proportion of wrong decisions). Many types of channel coding

schemes exist, some more powerful than others. The process is similar to sending a message and then adding all the consonants at the end. (For example, OVER THE WALL! + OVRTHW!) The cost to the system is a considerable number of extra bits in the channel.

► **Voice coding:** Voice coding, common to all types of digital radio systems, is the process in which an analog voice waveform is digitized and then coded to

remove redundancy. Numerous ways to encode voice have been identified. A general tradeoff exists between the perceived quality of the voice recovered in the receiver and the number of bits needed to encode the voice. Because the process of recovering the original voice waveform requires a detailed knowledge of how the encoding was performed, both the receiver side and transmitter side functions are performed in the same chip or software module. As a narrowband service, land mobile radio confines itself to so-called low-rate voice coding processes, which favor low data rates with sacrifice to the perceived quality from the receiver. Digital FM broadcast services are exactly the opposite. They employ the highest rates possible to get excellent music reproduction.

► **Equalization:** An equalizer, found in most digital receivers, removes the ISI (intersymbol interference) that the radio channel imparted to the signal from the

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Voice coding...is the process in which an analog voice waveform is digitized and then coded to remove redundancy.

transmitter. The radio channel represents a linear, band-limited process that can be looked upon as a filter that spreads a symbol's influence into the previous and next symbols' times. If left uncorrected, the receiver's decision circuits would cease to function.

Equalizers in digital radios are much more complex than their simple analog cousins. Low-cost advances in DSPs (digital signal processing) and analog-to-digital converters have made digital radio affordable.

Looking ahead

The road to reliable digital radios is well-marked into the future. The field of land mobile radio will witness an increased effort to use spectrally efficient modulation through digital means. The radio networks will become more intelligent and efficient in their ability to automatically test all parts of the radio system. As a result, technicians will spend less time testing and repairing radios, and spend more time optimizing whole radio systems.



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Circle (42) on Fast Fact Card



Technically speaking

(continued from page 8)

problem, I asked Hilton to disconnect this line protector and to wire the telco line straight into the base station tone-termination panel.

Though neither of us was expecting to see any positive results from this procedure, we had nothing to lose. After Hilton made the change, the dispatch console sent 10 consecutive keying signals down

the line to the transmitter.

"Okay Hilton, how many times did the transmitter key?"

"Ten for ten," came the enthusiastic reply from Hilton. Then a few seconds of dead silence on both ends—neither of us could believe that we had overlooked this innocuous device for so long! Hilton made some ac voltage measurements and

found the ac voltage (60Hz) on the line to be high. This accounted for the "fan-voice" effect. Apparently, the ac voltage was causing the line protector components to "fire," which caused distortion preventing the tone-termination panel circuitry from recognizing the keying signal.

The Solution

Obviously, we couldn't leave the base station hooked to the telco line without any lightning protection device connected, so a means of eliminating the 60Hz ac voltage had to be found. In a conversation with some of the telco personnel, Hilton learned about a special filter that telco technicians use on occasion to eliminate certain line interference problems. Telco loaned us three filters to use on a trial basis. Unfortunately, the filters did not eliminate the interference problem, but they did lead to the solution. Hilton contacted the manufacturer of these filters only to learn that better filters were available to combat the 60Hz "power influence" problem.

Having made the call to SNC Manufacturing, Oshkosh, WI, Hilton soon had the proper filters in hand. In each case, the filter was installed between the line protector and the line itself. The result was amazing. The transmitters would now key reliably even with the line protector in line. Figure 2 on page 8 shows a block diagram of the circuit after the installation of the SNIX filter (Single Noise Interference Xterminator) from SNC Manufacturing, as shown in Photo 1 on page 8.

Summary

Something can be learned from this—never be surprised at what you might find on a leased telco line. Expect the unexpected! Check for any induced 60Hz ac voltage on the line. Check for any dc voltage. Measure across the line and from each leg to ground. Check the line loss over the audio frequency range and especially at each of the control tone frequencies. Where bidirectional amplifiers are used, the loss and response tests should be conducted in both directions and compared. In short—be thorough.

Further information on these filter products can be obtained from SNC Manufacturing, 101 W. Waukau Ave., Oshkosh, WI 54901, or call them at 1-800-558-3325. Information is also available from SNC from their website at: www.sncmfg.com.

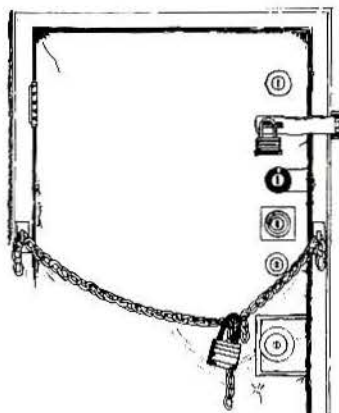
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By Robert H. Schwaninger Jr.

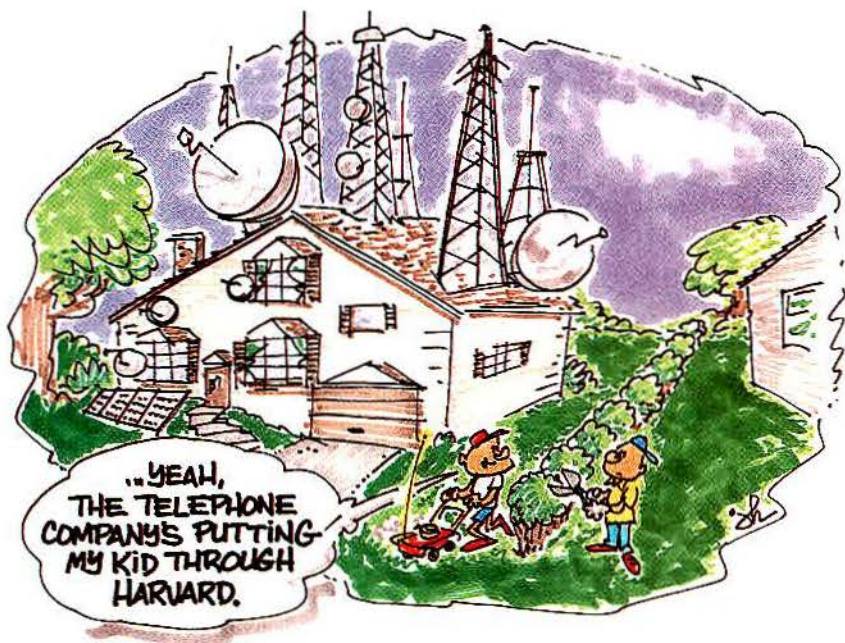
I've got a wry smile on my face as I bang out this month's column. The topic for this month is, "Who's the carrier, anyhow?" or "Who's serving whom?" The players in this political opera are a star-studded line-up that includes none other than Southwestern Bell Telephone (SWBT) and its list of accounts receivable.

Here's the story. On April 25, 1997, SWBT sent a letter to Regina Keeney, chief of the FCC's Common Carrier Bureau. In its letter, Southwestern Bell asked Chief Keeney whether the FCC would mind if the phone company collected some overdue bills from a few paging business customers that included AT&T, AirTouch Paging, PageNet and some other luminaries. It seems that some of SWBT's largest

customers were refusing to pay for the phone service used to terminate paging traffic.

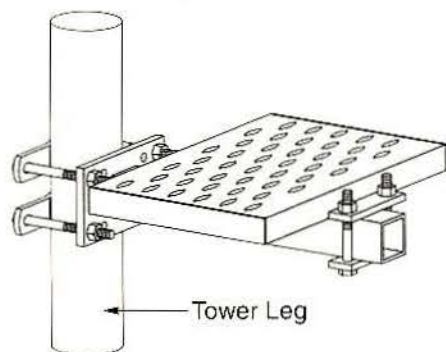
In a later letter responding to Southwestern Bell's earlier correspondence, the pa-

simonious paging companies explained why they were ducking SWBT's collection department. They pointed out that in 1996 Congress changed the language of the Telecommunications Act, and, in



Schwaninger, MRT's regulatory consultant, is a partner in the law firm of Brown and Schwaninger, Washington, DC. He is a member of the Radio Club of America.

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Circle (59) on Fast Fact Card

Regulating technology

Section 251(b)(5), the Act now says that local exchange carriers (LECs) are prohibited from charging commercial carriers for terminating traffic that originates on the LECs' networks.

Southwestern Bell has argued that it is not attempting to charge for the traffic, it is only trying to recover costs for the "facilities" to carry the traffic to the paging companies.

Huh?

Oh, I've got it. That's like the cable television company telling you that it's not charging you for HBO, it's just charging you for the use of the satellite downlink that just happens to carry HBO. The fact that the rate is the same as if you were paying for HBO is just a coincidence that could be easily cleared up—if you could just see it correctly.

The issues surrounding this little tiff between industry behemoths get extremely

philosophical and esoteric: If a person picks up a phone and dials a pager number, who is being served and by whom? Because I majored in Zen and diesel mechanics at Harvey's School For Frustrated Journalists, I'll take a shot at this one.

When the customer, let's call him Mortimer, picks up the phone, he's placing an order with the phone company. He has dialed a number, and the phone company has guaranteed Mortimer that his call will be routed through its wires and switches to some unit that is connected to the phone system for receiving the call. The call might go to Mortimer's mom's telephone set, Don Imus' fax machine, the psychic hotline or a paging terminal.

Assuming that the order is successful, Mortimer's call will be received, and communication of some sort will happen. According to the Telecommunications Act, if Mortimer's call is routed to a commercial carrier of communications, say "Acme Paging," the phone company is prohibited from charging Mortimer and Acme Paging. Mort picks up the tab as a part of his phone service.

Congress seems to think that this arrangement is fair because it's the phone company's customer that initiated the request for service. The paging customer didn't ask Mort to call. (Come to think of it, if a call goes to [instead of from] a cellular customer, that cellular customer didn't ask for that particular service either. *Hmmm.*) In a nutshell, Congress said that if your customer is the one demanding service, you can't charge other carriers for your use of their system to meet that demand.

This use of commercial logic is a radical departure by regulators from their long history of ignoring the basic tenets of contract law. In fact, it's incredible! When you provide service to a customer, you expect that you will have to pay all suppliers that create the necessary inventory of goods and services to fulfill the demand. You pay the telephone company, the electric company, the site lessor and a host of other people to deliver services to your customers. Only the phone company was allowed to charge its customer. Mort, and the commercial supplier of the service that Mort demanded.

At the core of this dilemma was the government's attempts to open up greater competition between LECs. The idea was that one LEC wouldn't charge another when the traffic originated on the first LEC's system. Or, as we used to say on the playground, "You started it!" But the ramifications of the statute could reach far beyond the competitive machinations of regional Bell operating companies

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Regulating technology

(RBOCs) and other wireline carriers.

Consider the effect on paging, commercial microwave, fiber-optic systems, LANs, interconnected private carriers, cellular, PCS, ESMR and more. If the carrier of a particular wireless service is deemed commercial, then the telephone company is not supposed to charge for terminating the call with the commercial carrier. In fact, the issue arises as to whether the commercial carrier could charge the tele-

phone company. This question is far from frivolous, and it is being discussed before the California Public Utilities Commission.

It is conceivable that telephone numbers used by paging and other wireless companies could become toll calls to offset the cost to telephone companies of using the wireless carrier's system to satisfy the demand of the telephone companies' customers. Someday, PageNet and AirTouch could be writing letters to the

FCC to complain about the fact that an RBOC had failed to pay its bill to the paging company, instead of the other way around.

The FCC has shown its courage in dealing with this situation by asking for comments on the subject. I expect that it will get a bunch of comments from both paging companies and telephone companies that are trying to protect their respective turfs. It might also get a few whispers from other commercial carriers who are aware of the kind of advantage that a favorable ruling on behalf of wireless carriers might reap.

Meanwhile, here's *my* scheme. I'm going to file a tariff with the local public utility commission to turn my customer premises equipment into a commercial entity that passes traffic to the extension in my den. Then I'm going to let it be known to every charity, aluminum siding salesman, real estate agent, lawn service company, religious cult and long-distance telephone company that I'd be happy to talk to them about their terrific products and services. Just to make sure that the phone keeps ringing, I'm going to run newspaper ads that suggest that a woman named Lola LaFlame will be waiting in my den to take calls. I figure I'll be able to send the telephone company charges that almost keep up with the weekly increases in my cable bill.

Following up...

I got a call the other day from a Nextel employee who works in the corporate communications office. He said that he had read my column regarding the company's difficulty in obtaining profitability (June *MRT*), which caused him to laugh off an important body part. According to him, the company was doing better than expected and had announced that it would likely move out of the red in the third quarter of 1998.

After congratulating him on the company's improved performance, I asked whether the predictions take into account interest payments that kick in at that time (to the tune of about \$50 million per year, based on Nextel's existing long-term debt of over \$3 billion). I didn't really get an answer to that question.

Instead, he predicted that I would have to "eat crow" about my comments about Nextel's financial struggle. I assured him that if Nextel's performance is as good as predicted, I'll be happy to consume, in public, a bit of the noxious bird. Bring on the black, beaked entrée and I'll happily chew a tune of "I'm Sorry," complete with Brenda Lee hairdo. Now, what's he going to do if I'm right?



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Educators, wireless industry players team to fill engineer and technician void

The FCC auctions of personal communications services (PCS) spectrum and the subsequent buildout of the networks have created a flurry of activity within the wireless industry. Not only are the PCS companies needing personnel, but so are cellular companies, specialized mobile radio (SMR) companies, paging companies and the myriad companies that maintain private land mobile radio systems.

Engineers and technicians with RF experience are at a premium as the demand for their services has grown, and there are simply not enough qualified people to do the work. The Personal Communications Industry Association projects that 300,000 new jobs will be created in the U.S. wireless sector by the year 2000. The question is: Who is going to fill them?

Enter the Global Wireless Education Consortium (GWEC). GWEC is a group of colleges, universities and wireless communications companies that have agreed to cooperate in the education of RF technicians and engineers. Membership is open to any business or individual related to the wireless industry and to schools of higher

education. The consortium began a little more than a year ago as a small group of wireless industry representatives and educators discussed the problem and the ways to solve it.

In March 1997, the consortium was incorporated. Now, the group has grown to six industry members and eight education members. Misty Baker, executive director of GWEC, said she expects to add 10 education members by the end of the year, and more schools, including three international universities, are in various phases of the application process.

"If we could get 100 schools adding a curriculum and saying they will graduate a minimum of 20 people out of these programs a year, we still will not meet the need, but we're certainly going to take care of a large part of it," Baker said.

Collaboration is vital

Colleges and universities applying to become members of the consortium must be approved by the board of directors. Academic participants must agree to include a wireless curriculum; they must agree to



Misty Baker



Paul Lindfors

work with industry members; they must agree to pass information along to other partners that join GWEC; and they must graduate a minimum of 20 students per year from sponsored programs within two years of joining the consortium.

"We want this to grow and increase, so the education partners must be willing to collaborate with others," Baker said. "The basis of all of GWEC is collaboration, so you have industry partners who are competitors and education partners who are competitors, and we're all coming to the table to share resources and work toward the common goal of increasing the quality and quantity of

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wireless technicians and engineers."

Industry members pay annual dues based on a sliding scale by gross revenues. They must also agree to share non-proprietary information with academic partners and to participate in curriculum development. They also contribute by offering internships for students. In turn, they will be able to draw employees from a continually expanding group of wireless-savvy graduates.

Wireless companies are spending an enormous amount of money educating technicians and engineers—bringing them up to a fundamental level—when, in reality, colleges and universities should be doing the educating, said Paul Lindfors, chair of the electrical engineering and electronic engineering and technology department at Mankato State University, Mankato, MN, a partner in GWEC. Wireless players should then take over and train their employees on proprietary matters.

GWEC is clear on the difference between education and training, and the lines are not crossed. Baker said that training belongs in the marketplace, and the business sector is not saying in any way, shape or form that the education sector should do its training. She said what they would like schools to do is the educational part—basic RF technology with as much exposure to current technology as possible.

"The industry people have taken on the whole educational aspect of it, so they're having to train people for maybe six to 12 months," Baker said. "The employees are a total liability at that point. They're not productive, and it's not good for anyone. So if the education can go back to the schools, then industry can do training on specific products."

Wireless focus

Both Mankato State University and

South Central Technical College (SCTC), a two-year college also located in Mankato, MN, were in on the ground floor of GWEC. The two-year electronics technology program curriculum at SCTC has been rewritten to emphasize wireless technology. The program at Mankato State was modified for the junior and senior years. Students study wireless communications during their basic communications course, and during their senior year they have telecommunications electives covering a broad range of subjects, wireless being one of the program options.

Seniors who choose the wireless option are required to complete a project showing they can apply what they have learned, said Lindfors. They must conceive, design, build and successfully demonstrate a project for the faculty, or they do not get their degree.

"We want industry people to give us the type of projects they want worked on that must require a team of at least one electrical engineer, at least one electronics engineering technology student and students from SCTC," Lindfors said. "Students are certainly going to go into an environment where time is important; money is important. We want to enforce this with our students as much as possible."

Consortium benefits

Baker said that GWEC is working on a plan to divide the schools into regions. The board is also asking that each four-year school pair with a two-year institution.

"At first I thought we'd have a real reaction to that," Baker said. "We're finding that the engineering departments and the universities are more than happy to work with the two-year schools, and it isn't for the purpose of taking the two-year student and moving them on to the four-year, because we want the two-year students to

become technicians and move on out into the workforce." She said what they can do is share curriculum, equipment, instructors and labs. "There are a lot of things they can do to eliminate duplication of effort and resources."

Other benefits of the consortium are seminars and internships. Baker said that GWEC is planning to host seminars at regional sites around the country so that those in the industry, as well as faculty and students, can learn the latest information. She said GWEC is also working on an exchange program between faculty and industry representatives in an effort to keep faculty members up to speed by giving them time in the industry for which they are preparing their students.

Another wireless program

Those colleges and universities involved with GWEC are not the only educational institutions attempting to increase enrollment while providing a boon for the wireless industry. The State University of New York Technical College at Canton (SUNY Canton) has introduced a two-year wireless technician program, which is based on the school's Electrical Engineering Technology program, to begin in the fall.

According to John Crary, dean of the School of Engineering Technology, the program will belong to the wireless industry, not to SUNY Canton. The program was designed jointly by the faculty and the advisory board, and each year the board will review the curriculum so that the school can teach the students exactly what the industry needs them to know. In return, the school asks that the partners support the program by donating equipment and assisting with student recruitment, scholarships and co-op program opportunities.

The program will blend theoretical and hands-on training for careers in fields such as two-way radio, digital paging systems, satellite communications and cellular. Employment opportunities include installation and repair, as well as electrical and mechanical design, technical sales and generating and releasing engineering documentation. The curriculum includes six wireless courses: Wireless Communications I-IV, Wireless Electronics and Wireless Communications Field Applications.

As part of co-op experience, students are expected to work in the industry during the summer between their first and second years. In the fall of 1997, the school will be developing internship sites for summer 1998. Crary said several advisory board members have already

GWEC Education Members

Mankato State University
Seattle Central Communication Colleges
South Central Technical College
University of Massachusetts at Lowell
University of Oklahoma
University of Texas
University of Washington
Washington State University

GWEC Industry Members

AirTouch
AT&T Wireless
Ericsson
Lucent Technologies
Motorola
US West

SUNY Canton program members

Arch Communications
Calian Technology
Ericsson
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Learning long distance

SUNY Canton has also been asked by several of its partners to provide remote instruction. Cray said the school is open to the idea and is willing to negotiate arrangements for its program to be accessed from remote sites via televised classes, teleconferencing, Internet courses or any other such

arrangement that would be beneficial.

SUNY Canton, like GWEC, is looking beyond the United States. Its advisory board includes members from Canada, and the school expects to recruit additional Canadian partners. It is also working with China to develop a partnership, and SUNY Canton representatives are having conversations with representatives in South America and Vietnam that may result in joint ventures there as well.



ITA criticizes 'Little LEO' proposals

The Industrial Telecommunications Association (ITA) has filed comments referencing two non-consensus recommendations presented by a working group of the WRC-97 Advisory Committee, dealing with the allocation of spectrum of low earth orbit (LEO) satellite communications.

Low-capacity (Little) LEO proponents are trying to secure international spectrum below 1GHz for new mobile satellite services that operate in a low orbit. As a result, a plan is being developed for sharing spectrum between the Little LEOs and existing radio services.

One of the draft proposals prepared by a working group of the advisory committee supported the allocation of additional spectrum for Little LEO uplinks in the 450MHz-470MHz band. This proposal, however, was not supported by the advisory committee. Noting that the band is currently being refarmed because of growing land mobile congestion, ITA said it was puzzled as to why the non-consensus proposal would advocate a Little LEO allocation that includes land mobile frequencies.

Calling it inconsistent with current International Telecommunications Union practices, ITA objected to the group's plan for the spectrum allocation to be broad enough to include individual countries' allocation tables.

Paging, narrowband industry disputes LEC interconnection position

The Personal Communications Industry Association's (PCIA) Paging and Narrowband PCS Alliance (PNPA), in comments filed with the FCC, vigorously opposed local exchange carrier (LEC) claims that paging carriers are required to pay LECs for LEC-originated traffic transported to paging networks.

The PNPA's comments were in response to a public notice released after the commission received requests by Southwestern Bell Telephone (SWBT) and some paging carriers to clarify its interconnection rules between LECs and paging carriers.

"The Telecommunications Act of 1996 and the FCC's rules clearly prohibit LECs from charging paging carriers for LEC-originated traffic," said Rob Hoggarth, PCIA's senior vice president, paging and narrowband. "This interpretation of the law has recently been upheld by the California Public Utility Commission and is acknowledged by a number of LEC players. We are confident that the FCC will eliminate any confusion that currently exists and induce the entire LEC community to abide by the Act."

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Nextel awards site development contract to Cord Communications

Cord Communications, Portland, OR, has been awarded the site development contract for Nextel Communications operations in Northern California and Southern Oregon.

As part of the agreement, Cord will provide in-house, turnkey services, including deployment strategy, program management, site acquisition, land-use planning,

civil construction and antenna system installation. Cord will manage and conduct the buildout process from start to finish on Nextel's behalf.

The Northern California and Southern Oregon buildout is part of Nextel's continuing nationwide expansion and will be served by Cord's new Sacramento, CA, and Medford, OR, offices.

MCI chooses AccessLink for integrated messaging device

MCI's business division has chosen Wireless Access' AccessLink wireless messaging unit for its recently launched narrowband PCS (N-PCS) messaging service offering, networkMCI interactive paging. The new wireless service provides nationwide messaging coverage with enhanced interactive reply capabilities in 16 major markets.

AccessLink allows for Internet email connectivity and custom message creation from

the device. MCI is marketing the new messaging service exclusively to business customers through its corporate sales force in its more than 250 branch offices across the country.

AccessLink is a two-way, belt-top wireless messaging device. Users may access Internet-based applications. The device allows users to create custom messages directly from an integrated keyboard.

Pyramid Communications purchases Nextel Carolina service shop

Pyramid Communications, Arlington Heights, IL, has purchased the Nextel Communications Service Shop in Greenwood, SC.

In addition to service capabilities, Pyramid Communications provides a full line of Motorola communications equipment including pagers, portable and mobile units, as well as base stations.

"Customers will now have the opportunity to order Motorola equipment and accessories locally, right in our service shop," said R. LaVance Carson, president of Pyramid Communications.

E.F. Johnson to build Yuma public-safety radio system

The City of Yuma, AZ, has awarded a contract for a new radio communications system to E.F. Johnson, Burnsville, MN. The 800MHz Multi-Net II trunking system will support all of Yuma's police and fire department operations and, eventually, city public works.

Phase One of the project is scheduled to begin immediately. E.F. Johnson will build a 10-channel primary repeater site and a five-channel backup site to provide 200 square miles of coverage within the Yuma city limits. Local E.F. Johnson dealer Gila

Chadmoore Wireless adds three cities to SMR operations

Chadmoore Wireless Group, Las Vegas, is now commercially operational in three additional cities, bringing the total number of markets in which it operates to 11.

The cities include Charlotte, NC; Mankato, MN; and Augusta, GA. The cities serve a total combined population of 1.2 million, bringing the total population covered by Chadmoore's 11 commercial cities to 4.6 million.

Chadmoore said it intends to have between 30 and 40 cities operational in its proposed operational footprint by year-end 1997.

Electronics will assist with installation and programming of 130 mobile and 230 portable radios for police and fire personnel. The city's existing dispatch consoles will be tied into the new system.

In Phase Two, E.F. Johnson will install its Summit dispatch console with 10 positions in Yuma's new dispatch center, interface the existing fire station alert system into the new center to the radio system's primary site and build a microwave link from the new dispatch center to the radio system's primary site.

Wireless phones used for more than 59,000 calls a day

Each day, more than 59,000 calls are made to 9-1-1 or other emergency numbers by wireless phone users, according to statistics released by Thomas E. Wheeler, chief executive officer of CTIA.

CTIA conducted a national survey of wireless phone carrier representatives and

emergency communications offices for 1996. According to the survey, 21,659,967 emergency wireless calls were placed during the year in the United States. This amounts to 1,804,997 per month, 59,180 per day, 2,466 per hour and 41 per minute.

IBM, Geotek join to upgrade Geotek's FHMA network

IBM, White Plains, NY, and Geotek Communications, Montvale, NJ, have signed an agreement to upgrade Geotek's existing network architecture supporting its commercial mobile radio system, which is based on Geotek's FHMA technology. Geotek markets bundled wireless mobile voice and data services, equipment and software programs that allow businesses to stay in contact with workers in the field, to track vehicles, to coordinate pick-ups and deliveries, to monitor assets and to exchange information.

IBM will provide systems upgrade and integration services, giving the infrastructure more capabilities, including an open interface with other wireless standards. IBM will also work with Geotek to develop and supply switching and switching control systems for the enhanced network to allow Geotek to broaden its market presence.

"What you're seeing in this announcement is a forward-looking view to say let's look at what we're doing to change how these companies are doing business as we integrate voice and data, as we pull the different pieces together, and let's go out and really solve their client problems," said Randall McComas segment executive, emerging markets, IBM.

IBM and Geotek have also signed a letter of intent to market Geotek's network services in conjunction with IBM services and products such as the IBM ThinkPads and software applications, allowing customers to access office systems from remote locations. The two companies have identified their first pilot customers in the Northeastern United States. More than 300 IBM customers will be targeted. Within these Northeastern accounts, the companies estimate a potential user base of 30,000.

SMR-WON's future up in the air

Since the International Wireless Communications Expo (IWCE) in April, members of SMR-WON have been questioning the usefulness of the association. Gene Stoker, chairman, said that the board members are split about 50-50 on the issue. Stoker says that although nobody he has talked to wants to throw in the towel, there is no consensus on which direction to take. He said about half would like to keep working as a separate association. The other half agree that the group's cause would be better served by joining forces with one of the other associations, but they do not agree on which association would be the best choice. At this point, the future of SMR-WON is up in the air, but members are encouraged to let their views on the issue be known.

Avtec receives public safety contracts for console systems

Avtec, Gilbert, SC, has received several public safety contracts for its DSPatch series of color touchscreen integrated radio and telephone console systems.

The State of North Carolina, Division of Emergency Management, ordered a 64-line DSPatch system with three operation workstations. The system is located in Raleigh, NC. Western Virginia Emergency Medical Services Department placed an order for a 64-line DSPatch system with three workstations for its regional dispatch center in Huntington, WV. Located in Bangor, ME, the Penobscot County Regional Dispatch Center has ordered a 64-line DSPatch system with six operator workstations. The City of DuBois, PA, has ordered a 32-line system with two workstations for the city's 9-1-1 center. The City of Hooksett, NH, Police Department has placed an order for a 32-line system with two operator workstations.

Winding up a three-year contract with the State of California's Highway Patrol, Avtec has completed the installation of 19 DSPatch systems at regional CHP dispatch centers throughout the state.

RF training group provides training for Wavetek

The RF Training and Technology Group, Dallas, has been appointed the national technical training resource for Wavetek Wireless Communications Division Distribution Network, Indianapolis.

Services being provided for Wavetek include a paging repair school, RF technology training (overview class), base station repair for paging applications and EDACS training for M/S testing and B/S testing applications. These classes are all 1½-day courses. The training group is also providing cellular handset repair training; cellular theory and site maintenance using TDMA, analog and CDMA; and applications of communications service monitors courses.

The training group also provides educational training courses to other communications providers including a radio certification course; mobile radio systems engineer, a course for radio systems engineers that covers engineering, economics, installations and interference; microwave systems engineer, paging systems, maritime systems, practical applications of oscilloscopes and two-way radio systems.

AMTA files for reconsideration of 220MHz rules

The American Mobile Telecommunications Association (AMTA) has asked the FCC to reconsider certain aspects of its recently released rules for the 220MHz industry to assure that regulatory parity exists between Phase I and Phase II licensees. AMTA has argued that the most important consideration for both categories of licensees is that their systems perform to a level that will enable them to attract and retain subscribers, both in coverage and service quality.

AMTA has asked the FCC to reconsider its announced rules for incumbent flexibility, to allow Phase I licensees the same flexibility that 800MHz and 900MHz SMR incumbent operators enjoy. The association also requested that the FCC modify the level of protection of incumbent non-nationwide systems to reflect the actual performance of 220MHz technology.

The association has argued that the rules adopted in the Order do not provide adequate protection between Phase I and Phase II licensees and has asked the FCC to modify the rules to reflect real-world conditions. Ongoing experience shows that a 28dBu contour better represents the reliable service area of a 220MHz system, rather than the FCC's permitted 38dBu contour. Based on this information, AMTA recommends that the FCC enlarge the minimum geographic separation between Phase I and Phase II licensees.

If the FCC fails to adopt co-channel protection criteria based on a 28dBu contour definition for 220MHz reliable service areas, with a 10dBu buffer zone, it would deny Phase I 220MHz licensees a quality of service comparable to other competitive wireless services, AMTA argued, and would lead to substantial areas of harmful interference.

Transcript to acquire E.F. Johnson

Transcript International, Lincoln, NE, has signed a letter of intent to acquire E.F. Johnson, Waseca, MN. In 1996, E.F. Johnson had revenues of \$79.3 million, and Transcript had revenues of \$13.8 million.

The letter of intent contemplates the acquisition of substantially all assets and the assumption of certain liabilities of E.F. Johnson for total consideration of \$34 million. In connection with the letter, Transcript and E.F. Johnson have entered into arrangements that include Transcript providing a \$2 million letter of credit, and E.F. Johnson entering into a licensing agreement that provides Transcript with certain intellectual properties of E.F. Johnson as the first step toward acquiring all of its assets.

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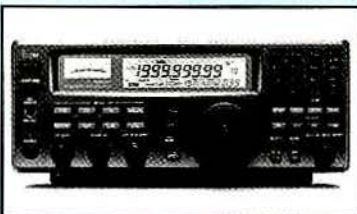


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Readers' choice

Of all the new products and services in the January 1997 issue, the one reprinted here generated the most reader requests for additional information. If you missed it the first time, here is your opportunity to acquire more information on it. Just circle the corresponding Fast Fact Card number on the card found in the back of this issue and mail the card to us.

Receiver includes 1,000 memory channels



The IC-R8500 all-mode, wide-band receiver from Icom America continuously covers a range from 100kHz to 2,000MHz, with 10Hz resolution. Coverage allows signal reception in SSB, CW, AM, AF and WFM modes. IF-shift and audio peak filter (APF) functions are built-in. A noise blanker, an RF attenuator and selectable AGC functions clarify the desired signals. The unit has 1,000 memory channels to store frequency, mode, tuning steps and RF ATT information. The channels are divided into 20 banks of 40, with 100 channels for auto-memory write scan and another 100 channels for skip scan. Scanning speed is adjustable to as many as 40 channels per second. RS-232C serial port allows direct computer control and monitoring receiver functions and levels.

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A.P.E.'s SRS-069 plating system is a compact and versatile electroplating station. It makes accurate plating operations clean and simple. Both cleaning and plating are accomplished with brush-tipped probes with grounding probe. The Quik Plate system uses a variety of materials from lead, tin and copper to nickel, gold and aluminum. It performs all original, repair and replacement platings.

Circle (301) on Fast Fact Card

Trunking protocol offers enhanced system administration

E.F. Johnson's LTR-Net is an advanced analog trunking protocol that is over-the-air compatible with existing LTR subscriber radios. It features more than 65,000 individual unit IDs and electronic serial numbers to prevent radio airtime piracy. LTR-Net offers enhanced system administration through its over-the-air ability to interrogate, put to sleep, disable and add channels to radios. This

wide-area capability is accomplished with new network switch components derived from E.F. Johnson's wide-area network product line for public safety. The enhanced network will offer immediate wide-area dispatch operation for existing LTR subscriber units. It will be fully compatible with the enhanced LTR-Net subscriber radios as they come on line.

Circle (302) on Fast Fact Card



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P30VD, P35VD, P40VD, P45VD	30-35, 35-40, 40-45, 45-50	<1.3	15	0	DGFET	\$ 44.95
P30VDG, P35VDG, P40VDG, P45VDG	30-35, 35-40, 40-45, 45-50	<0.5	26	+12	GaAsFET	\$109.95
P150VD, P160VD, P170VD	150-160, 160-170, 170-180	<1.5	15	0	DGFET	\$ 44.95
P150VDA, P160VDA, P170VDA	150-160, 160-170, 170-180	<1.1	15	0	DGFET	\$ 56.95
P150VDG, P160VDG, P170VDG	150-160, 160-170, 170-180	<0.5	24	+12	GaAsFET	\$109.95
P450VD, P460VD	450-460, 460-470	<1.8	15	-20	Bipolar	\$ 49.95
P450VDA, P460VDA	450-460, 460-470	<1.2	16	-20	Bipolar	\$ 74.95
P450VDG, P460VDG	450-460, 460-470	<0.5	16	+12	GaAsFET	\$109.95
P800VDG, P830VDG, P860VDG	800-830, 830-860, 860-890	<0.6	19	+12	GaAsFET	\$119.95
Inline (rf switched)						
SP30VD, SP35VD, SP40VD, SP45VD	30-35, 35-40, 40-45, 45-50	<1.4	15	0	DGFET	\$ 74.95
SP30VDG, SP35VDG, SP40VDG, SP45VDG	30-35, 35-40, 40-45, 45-50	<0.55	26	+12	GaAsFET	\$139.95
SP150VD, SP160VD, SP170VD	150-160, 160-170, 170-180	<1.6	15	0	DGFET	\$ 74.95
SP150VDA, SP160VDA, SP170VDA	150-160, 160-170, 170-180	<1.2	15	0	DGFET	\$ 86.95
SP150VDG, SP160VDG, SP170VDG	150-160, 160-170, 170-180	<0.55	24	+12	GaAsFET	\$139.95
SP450VD, SP460VD	450-460, 460-470	<1.9	15	-20	Bipolar	\$ 79.95
SP450VDA, SP460VDA	450-460, 460-470	<1.3	16	-20	Bipolar	\$104.95
SP450VDG, SP460VDG	450-460, 460-470	<0.55	16	+12	GaAsFET	\$139.95

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Circle (78) on Fast Fact Card



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Circle (79) on Fast Fact Card

New products

CDMA pilot scanner reports channels' power delay profiles in real time, measures pilot strength

The Scout from Berkeley Vari-
tronics Systems surveys all CDMA pilot channel signals and reports their power delay profiles in real time. The power delay profile represents the base station pilot power from both direct



and multipath signals from all base stations and indicates the distribution of pilot power vs. delay. The Scout can measure pilot strength (E_c in dBm), noise (I_0 in dBm) and E_c/I_0 for all direct and multipath pilot signals. The Scout features custom highly-pipelined hardware for fast (a complete survey of all PN positions can be completed in 27ms) real-time measurements and is packaged in a mobile case for field measurements. The Scout features complete and fast pilot channel characterization independent of network parameters, analysis of performance via independent measurement of E_c for direct and multipath components of I_0 and identification of pilot pollution, rogue pilot PNs and island cells.

Circle (303) on Fast Fact Card

T-series 2W and 5W RF loads perform to 6GHz



Bird Electronic's line of 50V, air-cooled RF loads includes new 2W and 5W models. These "T-series" loads are conservatively rated, with specified power handling at 40°C. At 25°C, power ratings are 2.4W and 6W, respectively. Connector options include male or female N, BNC and TNC. VSWR is 1.10 or better from dc to 1GHz for all models. With N connector, maximum VSWR is 1.25:1 at 1GHz-6GHz (1GHz-4GHz for BNC and TNC connectors). These loads are manufactured with non-magnetic materials throughout and are finished in silver or tri-alloy plating.

Connector options include male or female N, BNC and TNC. VSWR is 1.10 or better from dc to 1GHz for all models. With N connector, maximum VSWR is 1.25:1 at 1GHz-6GHz (1GHz-4GHz for BNC and TNC connectors). These loads are manufactured with non-magnetic materials throughout and are finished in silver or tri-alloy plating.

Circle (304) on Fast Fact Card

UHF repeater responds to trunking market

The KSG 4500 from Kenwood Systems Group is a fully integrated 100W, UHF repeater. Compatible with the full line of KSG controllers, both trunked and conventional, the UHF 100W repeater responds to the growing UHF trunking market. The KSG 4500 includes the amplifier and power supply in a compact package, designed to fit an EIA standard 19" rack.

Circle (305) on Fast Fact Card

Analog portable radio offers SmartNet trunking

Transcrypt International's Phantom analog portable radio is available in VHF, UHF and 800MHz and is fully field-programmable using the built-in keypad and allowing features such as RF frequencies, CTCSS and DCS to be changed. The Phantom offers top-mounted rotary knobs, dual backlit alphanumeric LCDs and a backlit keypad. For integration into high-tier Motorola radio systems, the radio comes with optional APCO 16-compliant SmartNet trunking. The radio can be equipped with Motorola DES and DES XL. It also includes built-in analog scrambling, allowing compatibility with other radios in the fleet using Transcrypt SC20-460 scrambling.

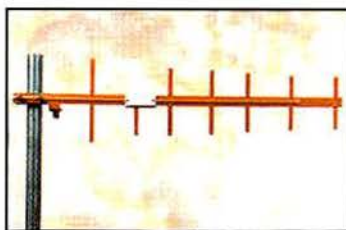
Circle (306) on Fast Fact Card

Portable radios provide 8 hours battery life

E.F. Johnson's 7500 series portable radios include multitone call guard and multicode digital call guard that provide signaling versatility for all conventional operations. Users of these portables have eight hours of battery life to cover a full work shift. The priority and normal scan functions ensure that calls won't be missed, and the 16 channels provide the flexibility for any size workforce. The 7510 model portable is a VHF (146MHz-174MHz) conventional radio with as much as 5W of RF power. The 7540 model portable is a UHF (400MHz-470MHz) conventional radio with as much as 4W of power. These 7500 series portables are compact, rugged and suitable for construction jobsites, warehouses, security, as well as public service applications such as police, fire and paramedics.

Circle (307) on Fast Fact Card

Yagi antenna withstands harsh elements



The ASPAR810 yagi antenna by the Decibel Products Division of Allen Telecom is for use in U.S. cellular bands from 824MHz-896MHz. The antenna is rugged and attractive because of its single-piece construction and gold anodized

finish. The antenna also offers precise signal control at 10dB gain in a 60° horizontal and 30° vertical beamwidth.

Circle (308) on Fast Fact Card

Signal processor reduces dispatch operator workload

The digital signal processor (DSP)-based universal dual channel card from Zetron's Public Safety Division features channel-check, an instant recall recorder option that captures for immediate playback four minutes of radio activity on each of the card's two channels. Recorder controls are intuitively integrated with the standard console controls (either button or CRT) for easy operation, and they include recorder enable, play/pause, rewind and reset. If channel activity occurs during this phase, playback is immediately suspended to ensure intelligibility of the incoming call. Channel-check reduces dispatch operator workload and decreases the incidence of requests for repeats.

Circle (309) on Fast Fact Card

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Circle (63) on Fast Fact Card

New products

Signal generators test CDMA, TDMA base stations for interference



Noise Com's BS-800 and 1900 dual interference signal generators facilitate interference testing of CDMA and TDMA base stations. These instruments include two synthesized CW signal generators and $\pi/4$ DQPSK signal generators and neces-

sary RF components to perform integrated testing of CDMA and TDMA. The CW and $\pi/4$ DQPSK signal generators are used for tone desensitization, intermodulation distortion, co-channel and alternate channel interference tests. Their frequencies are tunable in 10kHz steps, and the power levels are controllable in 0.1dB steps. Available in cellular frequencies as well as PCS frequencies, the BS-800 and 1900 series can be used with the MP-2500 multipath fading emulator and UFX-BER carrier-to-noise (C/N) generator, completing a full base station test setup.

Circle (310) on Fast Fact Card

Three-piece mobile computer creates mobile office environment

The Mobile Workstation 520 from Motorola's Worldwide Data Solutions Division is a rugged, three-piece mobile computer that combines the flexibility of a wireless data terminal with the power of desktop computer, creating a mobile office environment for in-vehicle users—particularly in public safety and field service organizations. The workstation is designed as three separate components that consist of a removable keyboard, a CPU with a 120MHz Pentium processor and capacity for as much as 32MB of RAM, and a large monochrome VGA display permitting visibility in all lighting conditions.

Circle (311) on Fast Fact Card

Cable and antenna analyzers reject RF interference

Anritsu Wiltron's S330A and S331A are two models in its Site Master cable and antenna analyzer line. The models, which offer segmented coverage from 5MHz to 3,300MHz, add wattmeter features to Site Master's existing SWR, return loss and distance-to-fault measurement functions. Both analyzers can reject external RF interference, allowing them to test at live sites and dense RF environments. This makes the models suitable for difficult testing applications, from HF communications to paging, cellular and PCS. The units isolate transmission faults using frequency domain reflectometry (FDR).

Circle (312) on Fast Fact Card

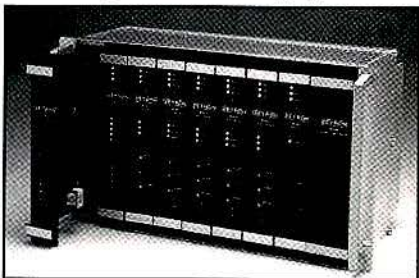
Keyboard offers backlighting



Texas Industrial Peripherals' Streetlight mobile keyboard offers a backlighting feature for low-light environments that may be turned on or off with a button. The backlighting option operates in three modes: 100% on, 50% on, or off and has a sleep mode, which activates after 60 seconds of non-use. The backlighting is provided by low-power LEDs. Current draw for the unit is 172mA with the backlighting at maximum intensity, and 10mA with the backlighting off. Enclosed in aluminum, the Streetlight is lightweight and sturdy. The unit measures 8.25"×0.95"×4.25". The 75-key layout supplies the standard alpha keypad and a set of 12 function keys.


Circle (313) on Fast Fact Card

LTR networking option works with range of mobile equipment



Zetron's LTR networking option is for the radio access control system (RACS) model 7032 radio channel switch. The RACS switch connects to Zetron's model 49 trunking repeater managers at widely separated sites to form an integrated wide-area LTR network. RACS/LTR networks offer users local and wide-area dispatch group calls, telephone interconnect and follow-me roaming throughout the system. RACS' auto-search assists in locating roving mobiles. RACS supports conventional channels providing seamless cross connection between radio networks and full PSTN or PABX interconnect. LTR for RACS works with a wide range of mobile, portable and repeater equipment, freeing system owners from sole source purchasing.

Circle (314) on Fast Fact Card




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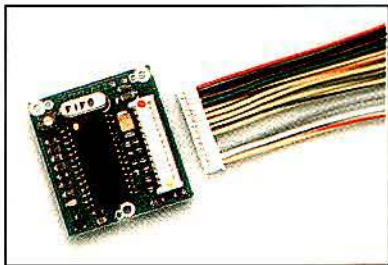
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Circle (65) on Fast Fact Card

Encoder module features 6 programmable memories

Pipo Communications' dual-tone, multifrequency encoder module, the AE-2, features six programmable memories. The miniature encoder module can be set to send as many as 180 digits in any conceivable



configuration of pauses, waits, delays, speed adjustments, transmitter PTT and memory loops. The module features non-volatile memory, 1kHz tone, speed adjustments of 5DPS, 10DPS, 20DPS or custom time base, CW ID option and 6Vdc-26Vdc at 0.5ma. Programmable features are configured through a compact hand-held programmer or on a PC with the Pipo interface box and accompanying software. Dimensions are 1"×1.1", 0.23" maximum height.

Circle (315) on Fast Fact Card

Recorder serves financial traders, emergency centers

Racal Recorders' eight-channel Wordnet Junior digital recording system is for message archiving and replay applications requiring lower call volumes and high-speed access. It takes less than one second search time for messages on the hard disk and less than 30 seconds for retrieving archived messages from digital audio tape (DAT). The system is suitable for any organization that needs to record as many as eight telephones or radios and instantly access essential calls, or for customers who need to archive all their voice messages and want the capacity and quick search performance offered by DAT. Telephone applications include monitoring malicious calls and security threats and recording calls in branch offices, brokers' offices, trading floors, call center, and lifeline-type telephone support operations.

Circle (316) on Fast Fact Card

HN series RF connectors offer various configurations

A full line of HN series plugs, jacks, receptacles and adapters for use with RG400, RG393, RG217 and RG218 cables is available from Tru-Connector. The HN series of RF connectors include straight and right-angle plugs and jacks for cables from 0.2" to 1.0" O.D., panel and bulkhead receptacles and in-series and between-series adapters. Capable of handling as much as 5,000V, these high-power connectors have an impedance of 50Ω and a dc-to-4GHz frequency range. Slightly larger than standard N-type connectors, these connectors use overlapping dielectric interfaces and dielectric creep paths.

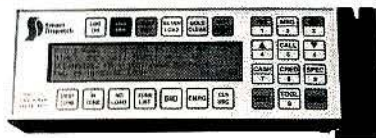


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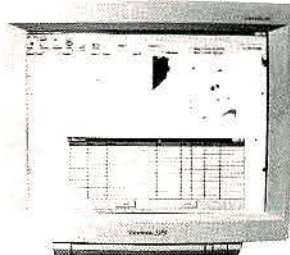
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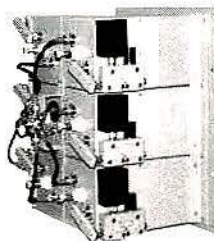
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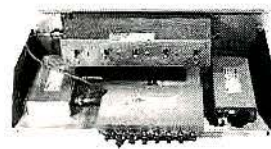
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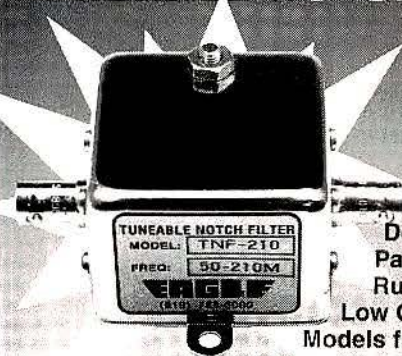
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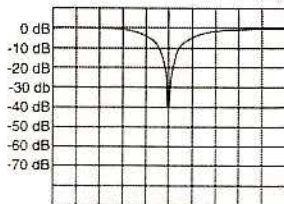
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The TNF200 filters are available in nine models from 0.5 MHz to 850 MHz. While primarily designed to improve the dynamic range of spectrum analyzers, these filters can also be used to reduce parasitics; or to eliminate or identify out of band interference in communications systems.



Plot of Typical Notch

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Circle (68) on Fast Fact Card

New products

Station provides on-line power protection

Liebert's UPStation GXT UPS adds to the existing UP-Station GX product line. The UPS GXT provides on-line power protection. It protects a wide variety of applications, including networks, clustered PCs and workstations, office telecommunications systems including voicemail and email, LAN, WAN and Internet servers, remote telecommunications units, test and diagnostic equipment and large network hubs, routers, gateways and bridges. This versatile UPS is suited to factory floor protection of microprocessor-controlled equipment. It is available in 700VA and 1,000VA mini-tower for 120Vac applications.



Circle (318) on Fast Fact Card

Laptop dock extends docking station life cycle



The SDI 8800 universal laptop dock from Scientific Dimensions extends the mobile docking station life cycle of any laptop computer. The dock provides flexibility for organizations planning to field follow-on generations of laptop computer equipment. The SDI 8800 includes

planned unobsolescence with a full universal, upgradeable and expandable mobile computer mounting system. It has a robust port replication with special rugged floating pin connectors that are good for more than 10,000 engagements. The dock features secure, tactile engagement when docking adapter plate to universal platform, and four modular configurations are available.

Circle (319) on Fast Fact Card

System records conversations from trunked radio

Swift Computers' logging recorder and retrieval system for trunked radio records and quickly retrieves coherent conversations at will from trunked radio systems. Two versions are available. One version, the SmartStor system, is for use with Motorola trunked radio systems such as Smartnet and Smartzone. The second version, the SwiftStor system, is for trunked systems such as LTR, EDACS, MPT-1327 and others. It will be available in the near future.

Circle (320) on Fast Fact Card

Option expands testing capability of radio communication analyzer



Anritsu Wiltron has expanded the testing capability of its MT8801B radio communication analyzer with the introduction of the IS-136 option. Now users can perform tests that previously required several interconnected instruments to the evaluation of all analog and TDMA transmitter and receiver parameters of the IS-136 digital cellular standard, including call processing. The analyzer also supports testing of GSM, DCS1800, PCS 1900, PHS and PDC. The MT8801B consists of an RF analyzer that covers the 10MHz-to-2.2GHz frequency range, signal generator covering 300kHz to 3GHz, modulation analyzer capable of <2% error, power meter and bit error rate tester.

Circle (321) on Fast Fact Card

Hand-held radios are programmable by channel

Uniden Private Radio Communications' hand-held portable radios (SPH255 and SPU554) bring many of the features and capabilities of the public safety radios to the business and industry customer. They are programmable by the channel for 12.5kHz and 15kHz narrow-band or 25kHz and 30kHz wideband operation. The radios have 99 channels, a backlit alphanumeric LCD and a DTMF keypad. The programmable feature allows compatibility with mixed narrow-band and wideband systems. Both models are compliant with a wide range of MIL-STD-810E tests, and an intrinsically safe option is available.



Circle (322) on Fast Fact Card

Distribution

Bolder Technologies has announced that **Excell Battery** has been chosen as Bolder's Canadian value-added distributor. Excell Battery is a battery modification center specializing in the design and assembly of custom battery packs for OEM applications.

For more information, call 303-422-8200, extension 556.

Maxrad antennas are now available from **Cartwright Communications**. The addition of this Ohio-based distributor brings Maxrad's total U.S. distribution network to 14 companies.

For more information, call 630-372-6800.

Transcrypt International has selected **ENC Federal** as a master dealer for Transcrypt's APCO 25 digital radio products. ENC Federal specializes in selling and servicing encrypted radio systems to the federal government and the U.S. military around the world.

For more information, call 402-474-4800.

SoloPoint's SmartMonitor call management system for mobile and virtual office workers will be distributed by **Hutton Communications**. Other SoloPoint products, SmartScreen and SmartCenter, will also be offered.

For more information, call 415-941-6282.

Lenbrook Wireless Communications is now Zetron's distributor for trunking products throughout Canada. The agreement covers a portion of Zetron's product line that includes trunking repeater controllers and wide-area networking solutions. Distribution of Zetron paging, business and industrial, public safety, RF monitoring and utility products is unchanged.

For more information, call 250-769-5604.

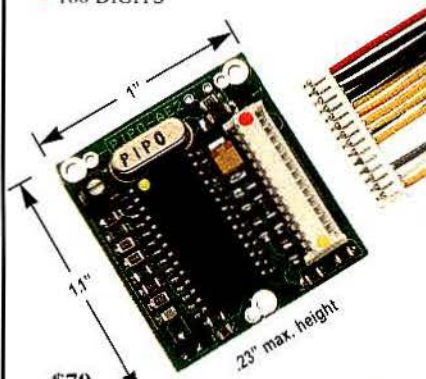
Testforce Systems is Marconi Instruments' new distributor for microwave and radio frequency (RF) test equipment throughout Canada.

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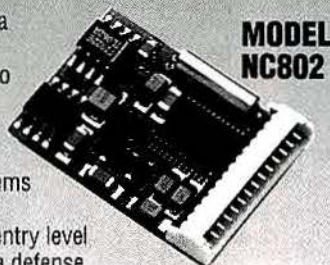


U.S. Patents 5,444,433 - 5,574,999 - D,377,795

Circle (70) on Fast Fact Card

VOICE SECURITY ENCRYPTION

The Model NC802 is a miniature inversion scrambler designed to provide intermediate level security for two-way radio voice communication systems and is a perfect, cost effective solution to entry level voice scrambling as a defense against unauthorized or casual listeners. The NC802 provides eight user selectable carrier codes commonly used by other manufacturers and interfaces easily to most radios with near transparency to the user.



MODEL
NC802

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product catalog call 1-800-874-8663

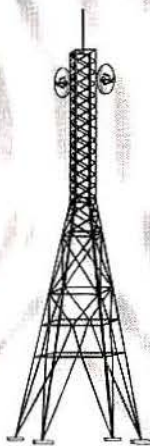


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Circle (72) on Fast Fact Card

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Circle (71) on Fast Fact Card

Literature

Book explains design of microstrip antennas

The book *CAD of Microstrip Antennas for Wireless Applications*, written by Robert A. Sainati and published by Artech House, provides in-depth information (with 280 equations) and tools necessary for computer-aided design of microstrip antennas for wireless and other commercial applications. Design engineers and engineering managers will find this technical reference helpful in developing an intuitive understanding of microstrip antenna operation—and mastering the necessary design steps. Software is included.

Circle (201) on Fast Fact Card

Catalog details switches for demanding applications

Otto Controls' 80-page catalog details more than 25 series of pushbutton, toggle, sealed rocker switches, sealed limit switches, special purpose, basic switches and domed shape pushbuttons and sealed pendant switches. Some Otto switches exhibit over a million operation cycle life. Otto switches are found in commercial, industrial and military applications and where six sigma quality and ISO 9001 registered facilities are required.

Circle (202) on Fast Fact Card

Land mobile radio catalog features antenna products

The 1997 *Land Mobile Radio (LMR)* antenna catalog from the Antenna Specialists Division of Allen Telecom highlights mobile antenna products and accessories including the Mosaic line of antennas and kit components. The booklet is part of a five-catalog set offered by Antenna Specialists. Each catalog addresses a different market: amateur, citizen band; land mobile radio, cellular and 800MHz-900MHz applications for SMR and ESMR trunking; and ISM band. The LMR catalog includes revisions to its product line including the ASP-1490 and ASP-690 series, which incorporate the Mosaic method of ordering, using kitting components for trunk-lid, snap-in and magnet-mount versions. Product updates include new all-black coils now featured in the ASP-268, ASP-177 and ASP-861 antenna series.

Circle (203) on Fast Fact Card

Guide highlights more than 100 wireless products

Zetron's 1997 *Product Guide* includes 56 pages of photos and descriptions of more than 100 wireless communications products and systems. The catalog contains DTMF mics, repeater controllers, remotes, paging terminals, alarms and control systems, RF specialty products and more. Many of the products serve as central controllers of a wide variety of mobile radio, pocket paging and telephone communications systems.

Circle (204) on Fast Fact Card

National repeater guide describes all GMRS repeaters

The 10th edition of the GMRS (General Mobile Radio Service) *National Repeater Guide* from the Personal Radio Steering Group describes all known or licensed GMRS repeaters—more than 3,400 in the U.S. The 270-page guide assists the GMRS traveler in obtaining local travel assistance or to report local highway emergencies. GMRS users can also use the guide to assist with resolution of local interference problems. Listings in the guide are organized by state and major urban or regional areas. For each repeater, information on operating channel, station address, coverage range and contact person mailing address and phone (to request operating permission) is listed. It also includes a cross reference by operational names. These specialized names are often used to identify local user groups and cooperatives.

Circle (205) on Fast Fact Card





Nelson



Zucker



Ferguson



Pantsios

Randy Nelson departs GP Batteries, San Diego, as national sales manager to join Multiplier Industries, Mt. Kisco, NY, as national sales manager, U.S. sales and marketing.

William Zucker, product line manager, moves up to vice president of marketing at Spectrian, Sunnyvale, CA.

Changes at ArrayComm, San Jose, CA:

William Ferguson exits Diva Communications, Oakland, CA, as senior field engineer to join ArrayComm as systems engineering manager.

Fred Pantsios departs Jampro Antennas, Sacramento, CA, as Latin American sales and marketing manager to join ArrayComm as sales applications engineer.

Changes at Plant Equipment, Temecula, CA:

Kenneth D. Adams leaves Axon Communications, Santa Ana, CA, as manager of software development to join Plant Equipment as senior software developer.

George Caspary exits Pacific Bell, Concord, CA, as senior engineer in 9-1-1 systems to join Plant Equipment as customer service project manager.

Martin Cooper, founder and chairman of ArrayComm, San Jose, CA, adds to his responsibilities by becoming a director of Wireless Access, Santa Clara, CA.

Bret A. Berg leaves AST Computer, Irvine, CA, as director of product marketing and brand management, mobile products, and joins AirMedia, Newport Beach, CA, as director of product management of mobile products.

Changes at Location Systems, Dallas:

Russell K. White departs Comdata-RoTec, Dallas, as national accounts manager to join Location Systems as sales manager for the On-Trac commercial fleet management products division.

Ruth Ann Ledbetter leaves her position as sales and marketing coordinator at the Auto-Trac Division of E-Systems/Raytheon, Arlington, TX, and joins Location Systems as sales manager for the company's on-line interactive consumer personal security and vehicle recovery system.

Changes at CNet, Plano, TX:

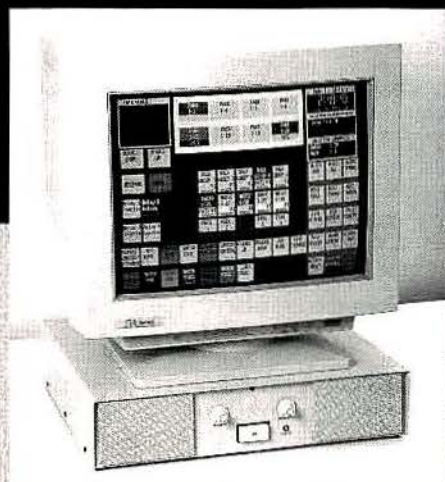
Zhujun Li leaves Alcatel Network Systems, Richardson, TX, as consultant to join CNet as software engineer.

Daniel Lo departs MCI, Richardson, where he was responsible for designing and implementing a software management system, to join CNet as software engineer.

Robert L. Simpson leaves his duties as consultant for companies such as Object Database Systems and the Texas Department of Human Services to join CNet as software engineer.



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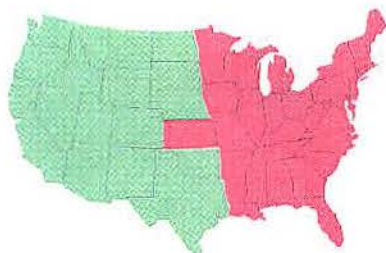
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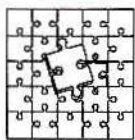
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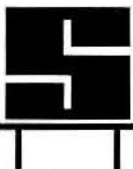
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20	MOTOROLA Starcom 2000 96-channel with hot-standby on	\$2,000 ea
	Free, 2 1412, 2 1912, 2 138, 2 188, 2 1816, 2 1316 and others	
5	UNKURT 7782 17-199 with hot-standby	\$1,000 ea
30	TELLABS 6923 2w. FKS-SF-SIG SET	\$100 ea
30	TELLABS 6924 2w. FKS-SF-SIG SET	\$100 ea
80	GRANGER DTL 7300 Channel readers with E&M Signaling S125 ca. (these are the ones with the white pull handle and dip switch programming)	\$100 ea
3	HARRISON FL-6 60Hz with hot-standby	\$4,000 ea
25	ADC jackfields with plug-type rear connections	\$100 ea
25	MOTOROLA Syntor-X 9000 mobiles 100w UHF	\$400 ea
400	DIRECTOR II papers with chargers UHF	\$20 ea
3	LARSE 1242A alarm panels	\$100 ea
30	MC-400 Channel modems	\$50 ea
6	ITT A325 60Hz with hot-standby	\$1,000 ea
8	HARRISON FL-2 17-1 90Hz (non-standby) with standby \$1,000 ea	
1000	Assorted TELLABS telecom signaling modems	\$CALL5
75	GTE LINKURT 46A channel modems	\$100 ea
80	ROCKWELL channel modems	\$100 ea
30	DTL-7300 Shelves (add-on S125) start-up	\$150 ea
50	MC-400 Term cards	\$50 ea
10	MOTOROLA Maxtrac 800 B-1	\$225 ea
10	TMX 8415 and MDS 60mk	\$150 ea
25	MOTOROLA SYNTOR XZ 100w UHF	\$300 ea
1	DICTAPHONE 5500 20-channel logging recorder	\$1,000
1	MOTOROLA Micor 42-50 PL 330w	\$1,800
50	MOTOROLA Micor 42-50 PL 60w	\$125 ea
10	STX Converta-Com with RF amp, speaker microphone 800MHz \$250 ea	
300	MOTOROLA Director Pager with charger and reeds UHF (lots of 10—\$75) (all for \$100)	
30	GE Master II 100w 42-50 with accessories	\$80 ea

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(FORMERLY WEST COAST RADIO)

Quantity	Equipment List	Price
2	SP50 P94Y0T2002 4w, 10 ch, 450-470	\$319
8	P110 P43QLC00A1 5w, 2 ch, 136-162	305
12	P110 P24QLC20A2 2w, 2 ch, 438-470	295
5	P110 P43QLC20A2 5w, 2 ch, 146-174	305
5	P110 P44QLC20A2 4w, 2 ch, 438-470	329
2	P110 P44QLC20B4 4w, 8 ch, 438-470	379
4	GP300 P93YPC20A2 5w, 2 ch, 146-174	395
15	GP300 P94YPC20A2 4w, 2 ch, 438-470	399
5	GP350 P94MGC20C2 4w, 16 ch, 438-470	519
5	GP350 P94MGC20A2 4w, 2 ch, 438-470	429
1	HT1000 H01KDC9AA3 5w, 16 ch, 136-178	499
14	HT1000 H01SDCVAA1 4w, 2 ch, 450-520	479
24	P50 H33GCU3120 2w, 2 ch, PL, BLGR DOT	179
5	P50 H34GCU3120 2w, 2 ch, PL, UHF	195
3	GM300 M44GMC29C3 40w, 10 ch, 438-470	449
7	UNDEN SP55H 5w, 8 ch, VHF 150-170	175

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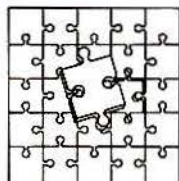
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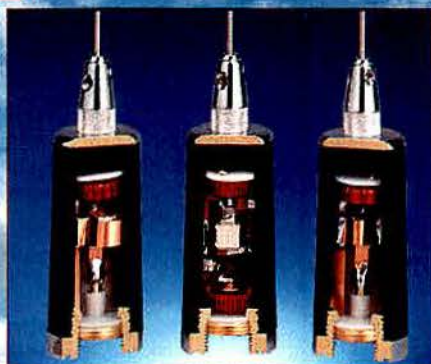
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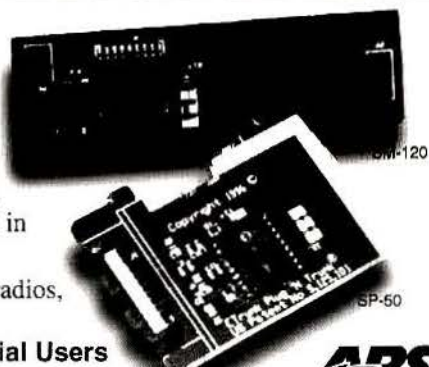
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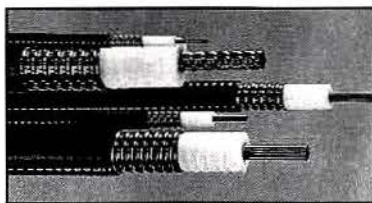
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MOTOROLA SYNTOR-X 450MHz, 100w, w/accy \$400
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As above for MARATAC (HLN1267) \$150
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MOTOROLA P200, MT1000, SABER belt clips \$7
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5	MOTOROLA	PP-100A, full duplex 800, trunked mobile	149
6	MOTOROLA	MAXAR 50, UHF, D34JA45300AK, w/o acc	75
4	MOTOROLA	SYNTHOR X, 11bw, 42-50, T71VBJD04AK, w/acc	275
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21	MOTOROLA	TRUXAR 800, trunked mobiles, D35TD45600DK, w/o acc	49
50	MOTOROLA	MAXAR 800, trunked mobile, w/line, w/acc, w/10 system (m/c)	75
2	MOTOROLA	MAXAR 80, UHF, mobile, w/PL	75
51	GE MASTER II	UHF, 40w, CG MC65KHUB8A, w/o acc	75
9	GE MASTER II	LB 60w, 42-50, MC64KF33NA, w/o acc	75
90	GE MASTER II	VHF 50w, 150-174, MC56KAU66A, w/o acc	75
1	GE MV5	UHF 450-470, 16 freq, 25w, NPJ20, w/o access	175
5	DELTA	EX 450-470, 40w, 25w, 20 control board	125
5	DELTA	SX 450-470, 40w, 25w, radio only	95
18	JOHNSON	CHALLENGER 1172, UHF, 488-512MHz, w/acc	125
29	JOHNSON	8600 800MHz, LTR, w/acc	175
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70	JOHNSON	8640 900MHz, LTR, w/acc	175
5	JOHNSON	8644 900MHz, LTR, w/acc	125
44	JOHNSON	8655 900MHz, LTR, w/acc	225
128	KENWOOD	TK-930 800MHz, LTR, w/acc	175
18	KENWOOD	TK-931 900MHz, LTR, w/acc	175
7	UNIDEN	SMS925TS, 900MHz, LTR	175
2	UNIDEN	SMS935TS, 900MHz, LTR	105
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1	MOTOROLA SABER I 450-470 21 freq. w/o charger	275	275
18	MOTOROLA MTX-800 1 system	250	4500
6	MOTOROLA MTX-800/810 2 system	275	1650
9	MOTOROLA MTX-9000, portable B3	250	2250
25	MOTOROLA MTX-900, H25HF51B1/B3/B4, 900MHz, multi-system portable	275	6875
1	MOTOROLA VISAR 800MHz portable, H05CUD4CB1N	195	195
1	MOTOROLA VISAR, 800MHz portable, H05CUDC6B1N	95	95
1	MOTOROLA GP-300, 155-174MHz	325	325
1	MOTOROLA MT-1000 16 freq. 450-470MHz w/rapid charger	325	325
2	MOTOROLA MT-1000 99 freq. 450-470MHz w/rapid charger	475	950
4	MOTOROLA RADIUS P-200 6 freq. 450-470MHz w/rapid charger	325	1300
12	MOTOROLA P-50 2 freq. 450-470 PL w/o charger	125	1500
8	ETX B403 800MHz G-Mark V portable w/rapid charger	195	1560
6	EMF VFO Vase Guard 450-470 portable w/battery, rapid charger and speaker mic	175	1050
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5	6 GE MASTER II 100w, 42-50 base, DC	850

5	GE MASTER ELECTUTIVE II 6T 42-50 base, w/DC cont	125
5	GE MASTER II aux receivers 42-50, 450-470	250
20	GE VOTING comparator, w/4 receiver modules	249
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1	MOTOROLA MSR 2000, VHF, 30w repeater	1,500
1	MOTOROLA MSR 2000, VHF, 30w repeater	1,500
5	MOTOROLA MICOR, C71RTB3105DT, 42-50 100w repeater	2,500
1	MOTOROLA MICOR, C71RTB3105CT, 42-50 100w repeater	1,500
8	MOTOROLA MICOR, 100w 42-50 DC base (unified chassis)	750
3	MOTOROLA MICOR base, 800MHz conventional 135RTB6100AM	1,725
1	MOTOROLA MICOR 72MHz transmitter, C42JB2E106AC	129
1	MOTOROLA MICOR, 72MHz base, desk mcs, DC control	495
41	MOTOROLA MAXTRAC/RADIUS, base mcs (NEW)	1,435
4	MOTOROLA, 43MHz, Pure Base, C71JB2-1106A	2,500
1	MOTOROLA MODEN, 100 paging terminal	20
2	MOTOROLA MODEN, 100 paging terminal	60
1	MOTOROLA EO8ENQ900AT, paging terminal	45
5	MOTOROLA SIMULCAST System Controller, T305IA	SCALL
1	QUINTRON Digital Control Unit	SCALL
20	AVANTek Digital 20W microwave w/aux & base	SCALL
5	STANDARD zero 15w 800MHz repeater, duplex	SCALL

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15	MOTOROLA MX-305, ConvertaCom, complete w/amplified speaker	49
15	MOTOROLA HT-220, 450-470 PL 4w, 5 freq. H34FFY3190B, less elements	25
4	MOTOROLA SP-100, 1000MHz, paper UHF	25
25	MOTOROLA PAGEBOV III, VHF	35
15	MOTOROLA PAGEBOV III, VHF	35
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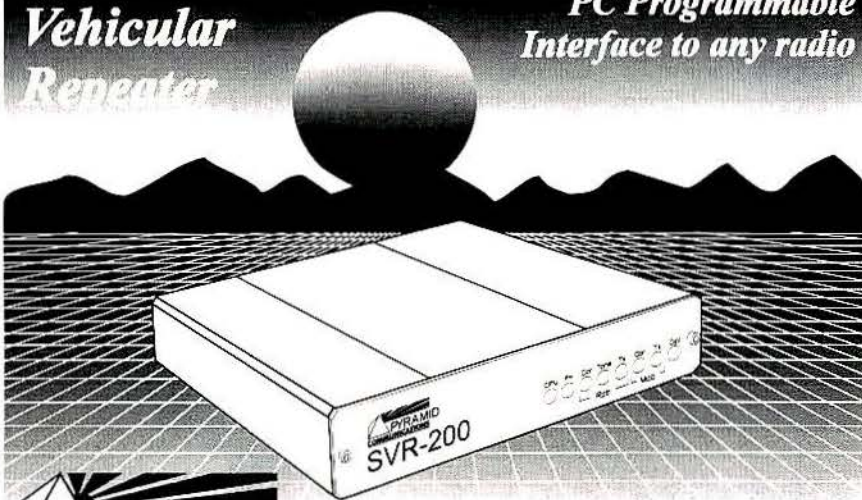
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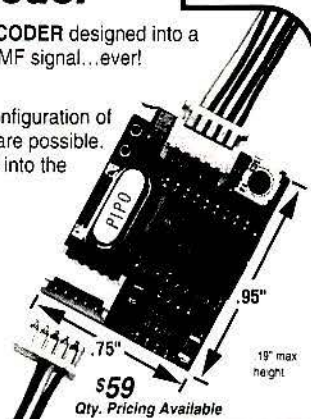
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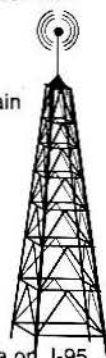
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